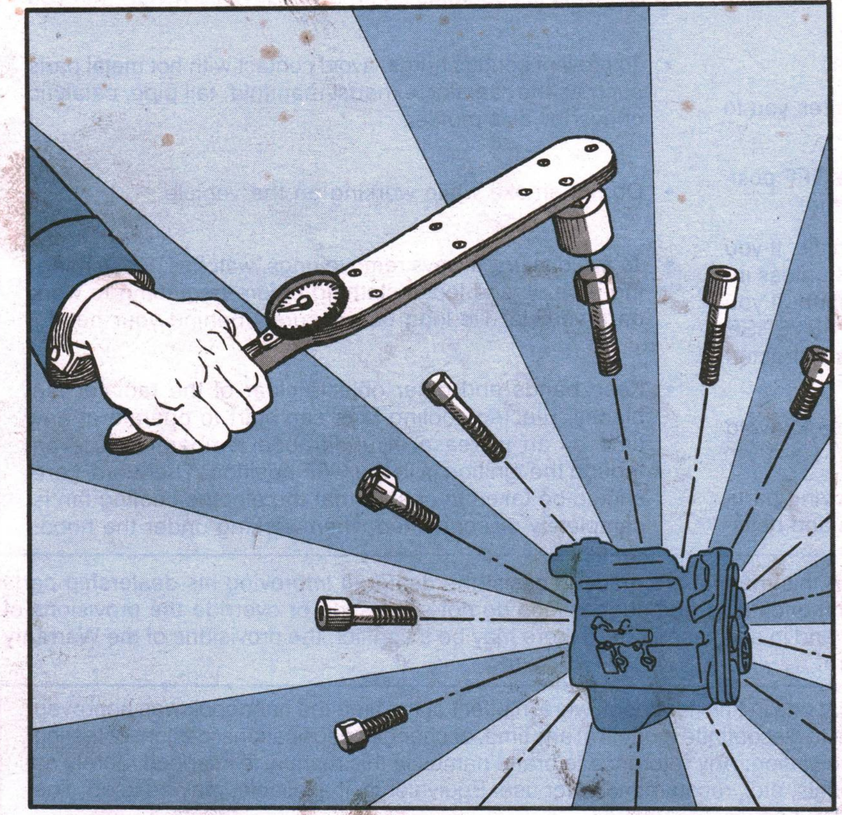
Fastening Devices and Torquing Techniques



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Ford Parts and Service Division
Technical Training

NOTE: The material in this student reference book contains information for all STST specialties.

IMPORTANT SAFETY NOTICE

Appropriate service methods and proper repair procedures are essential for the safe, reliable operation of all motor vehicles, as well as the personal safety of the individual doing the work. This manual provides general directions for accomplishing service and repair work with tested, effective techniques. Following them will help ensure reliability.

There are numerous variations in procedures, techniques, tools, and parts for servicing vehicles, as well as in the skill of the individual doing the work. This manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Accordingly, anyone who departs from instructions provided in this manual must first establish that he compromises neither his personal safety nor the vehicle integrity by his choice of methods, tools, or parts.

As you read through the procedures, you will come across NOTES, CAUTIONS, and WARNINGS. Each one is there for a specific purpose. NOTES give you added information that will help you to complete a particular procedure. CAUTIONS are given to prevent you from making an error that could damage the vehicle. WARNINGS remind you to be especially careful in those areas where carelessness can cause personal injury. The following list contains some general WARNINGS that you should follow when you work on a vehicle.

- Always wear safety glasses for eye protection.
- Use safety stands whenever a procedure requires you to be under the vehicle.
- Be sure that the ignition switch is always in the OFF position, unless otherwise required by the procedure.
- Set the parking brake when working on the vehicle. If you have an automatic transmission, set it in PARK unless instructed otherwise for a specific service operation. If you have a manual transmission, it should be in REVERSE (engine OFF) or NEUTRAL (engine ON) unless instructed otherwise for a specific service operation.
- Operate the engine only in a well-ventilated area to avoid the danger of carbon monoxide.
- Keep yourself and your clothing away from moving parts when the engine is running, especially the fan and belts.
- To prevent serious burns, avoid contact with hot metal parts such as the radiator, exhaust manifold, tail pipe, catalytic converter and muffler.
- Do not smoke while working on the vehicle.
- To avoid injury, always remove rings, watches, loose hanging jewelry, and loose clothing before beginning to work on a vehicle. Tie long hair securely behind your head.
- Keep hands and other objects clear of the radiator fan blades. Electric cooling fans can start to operate at any time by an increase in underhood temperatures, even though the ignition is in the OFF position. Therefore, care should be taken to ensure that the electric cooling fan is completely disconnected when working under the hood.

The recommendations and suggestions contained in this manual are made to assist the dealer in improving his dealership parts and/or service department operations. These recommendations and suggestions do not supersede or override the provisions of the Warranty and Policy Manual or the Shop Manual and in any cases where there may be a conflict, the provisions of the Warranty and Policy Manual or the Shop Manual shall govern.

The descriptions, testing procedures, and specifications in this handbook were in effect at the time the handbook was approved for printing. Ford Motor Company reserves the right to discontinue models at any time, or change specifications, design, or testing procedures without notice and without incurring obligation. Any reference to brand names in this manual is intended merely as an example of the types of tools, lubricants, materials, etc., recommended for use. Equivalents, if available, may be used. The right is reserved to make changes at any time without notice.

WARNING: Many brake linings contain asbestos fibers. When working on brake components, avoid breathing the dust. Breathing the asbestos dust can cause asbestosis and cancer.

Breathing asbestos dust is harmful to your health.

Dust and dirt present on car wheel brake and clutch assemblies may contain asbestos fibers that are hazardous to your health when made airborne by cleaning with compressed air or by dry brushing.

Wheel brake assemblies and clutch facings should be cleaned using a vacuum cleaner recommended for use with asbestos fibers. Dust and dirt should be disposed of in a manner that prevents dust exposure, such as sealed bags. The bag must be labelled per OSHA instructions and the trash hauler notified as to the contents of the bag.

If a vacuum bag suitable for asbestos is not available, cleaning should be done wet. If dust generation is still possible, technicians should wear government approved toxic dust purifying respirators.

OSHA requires areas where asbestos dust generation is possible to be isolated and posted with warning signs. Only technicians concerned with performing brake or clutch service should be present in the area.

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Produced and Coordinated by
Joseph C. Barney, Jr.
Technical Training
Ford Parts and Service Division

WHAT YOU SHOULD KNOW ABOUT TECHNICIAN SPECIALTY TRAINING

The Key — SPECIALTY...

STST changes the approach to training by specifically identifying and tailoring training according to your chosen specialty.

Ford Parts and Service Division will offer a series of courses tailored for your specialty. Courses will be scheduled at your District Service Training Center.

When you have completed this group of courses, you will be recognized as the specialist technician that you are!

The Path — A NEW CURRICULUM...

To support STST, a new curriculum is being prepared to provide you with more thorough, job-related training. Courses are designed with more depth, more hands-on training, more skills testing and more shop time — just like the EEC-IV and the Automatic Transmission classes now offered.

The Bottom Line — CUSTOMER SATISFACTION...

STST courses are designed to enable technicians to diagnose and repair customers' vehicles the first time with knowledge of the system and confidence in the repair.

This spells the best satisfied customers in the world!

BE A PART OF IT...SEE THE NEXT PAGE FOR THE STST CURRICULUM.

Course Requirements By Service Specialty

STST Curriculum	Service Specialties								
	Engine Performance 31	Engine Repair 32	Suspension & Steering 33	Electrical Systems 34	Climate Control 35	Manual Transmission and Drive Train 36	Automatic Transmission and Drive Train 37	Brakes 38	Pre-Delivery 39
Electrical Systems (5 days)†	X[1]	O	X[1]	X	X[1]	O	X	X[1]	O
Gas Engine Operations (4 days)†	X	X							
Electronic Engine Control (5 days)†	X								
Advanced Engine Performance (2 days)†	X								
Diesel Engine Operations (4 days)†	O[2]	X[2]							
Engine Repair (4 days)	O	X							
Suspension (2 days)†			X						
Steering (2 days)†			X						
Brake Systems (2 days)†								X	
Climate Control Systems (3 days)†					X				
Manual Transmission (2 days)						X			
Rear Axle & Driveshaft (1 day)						X			
NVH (1 day)†			X			X			
Automatic Transmission Rear-wheel Drive (5 days)†							X		
Automatic Transmission Front-wheel Drive (5 days)†							X		
Automatic Transmission Advanced Diagnostics (2 days)							X		
Pre-Delivery (1 day)†									X

O = Optional, but recommended
†Courses available for training in 1990
[1] Prerequisite course
[2] Ford Dealers

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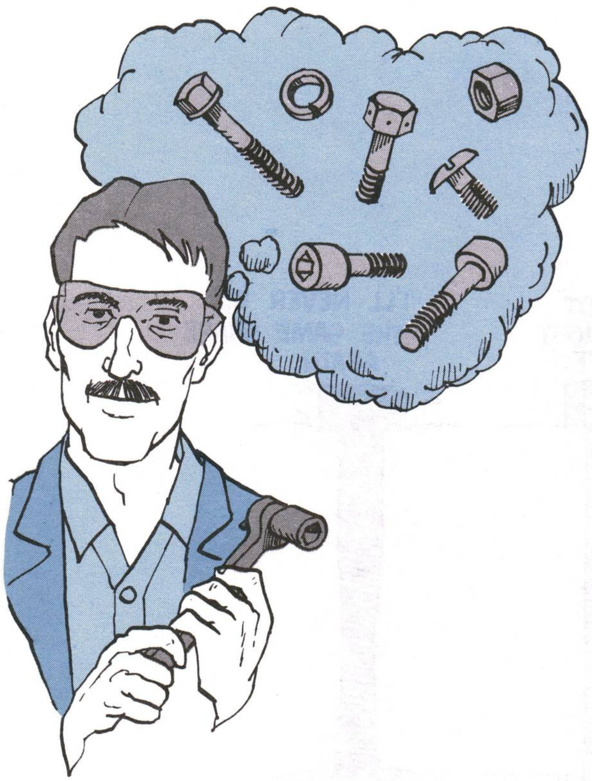
INTRODUCTION

This video training course provides the technician with the information that relates to fastening devices, bolt identification, torque, torque wrench usage, de-torque methods, and torque methods. This reference book concentrates on the engine related components but the concepts apply to all fastener applications.

Fastening devices are one of the most critical but least understood parts of a vehicle. Improper tightening causes most fastener related failures. Improper use of fasteners can result in extensive engine damage and costly repeat service.

Design changes in the newer engines make having an understanding of fasteners even more important. Structural changes and the use of lighter metals increase the chances of damaging engine components during removal and replacement procedures.



OVERVIEW

This video reference book will discuss the following information about fastening devices and torque procedures:

- Types of fasteners
- Fastener identification
- Fastener characteristics
- Thread identification
- Torque concepts
- Torque wrench usage
- Torque variations
- Torque and component relationship
- Torque procedures
- Torque to yield method
- De-torque procedure

TECHNICIAN'S OBJECTIVES

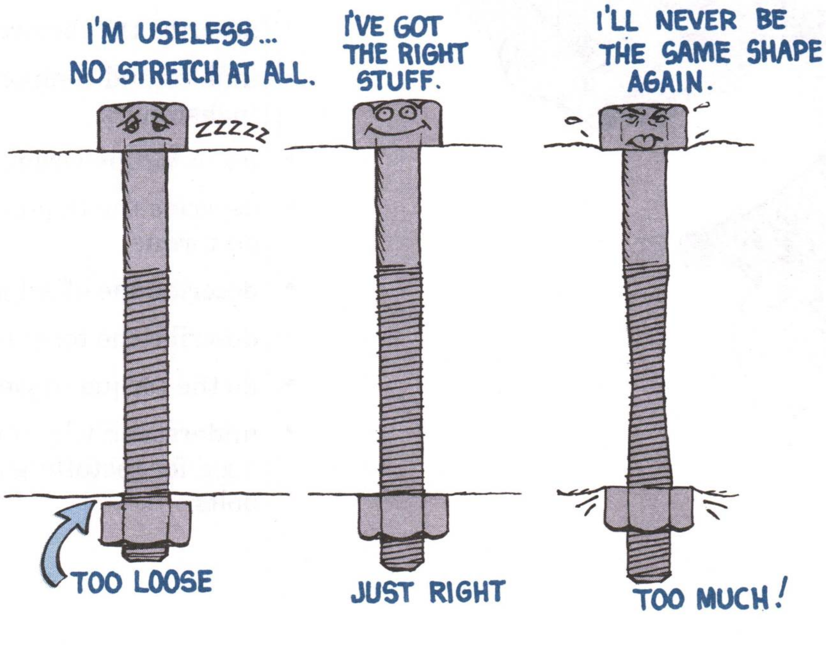
After this video training course the student can:

- understand the concepts of bolt stretch and clamping force.
- identify the differences in bolts.
- measure bolt diameter and thread pitch.
- understand the use of thread sealers and adhesives.
- describe the factors that affect torque.
- understand component failures related to fasteners.
- use a torque wrench properly.
- describe the importance and method of de-torque.
- describe the effect gaskets have on torque.
- describe the torque to yield theory.
- do the torque to yield method.
- understand why impact wrenches are not used for installing or removing engine bolts.

THREAD STRETCH

The function of a threaded fastener is to provide a force to hold two or more surfaces together. Stretching the fastener allows this force to be developed. As a bolt tightens, the exposed threads stretch and the bolt becomes longer. Tightening the bolt more causes the threads to stretch further. This stretching action allows the bolt to deliver the force needed and remain tight when exposed to temperature changes and vibration.

Proper tightening allows the bolt to return to its original size when loosened. Over-tightening will cause the bolt to weaken or break. Excessive tightening causes the bolt to stretch permanently and "neck down" in the threaded length. Under-tightening causes the bolt to loosen and fail to do its job. Extensive research goes into determining required bolt size and how much to tighten it.

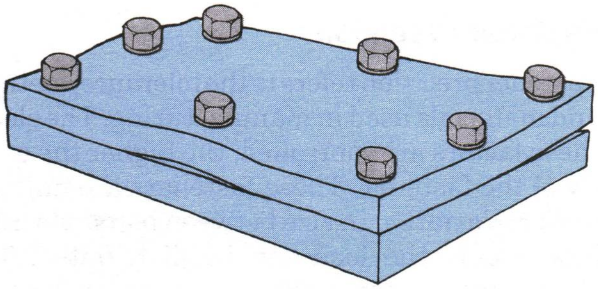

I'M USELESS...
NO STRETCH AT ALL.
ZZZZZ
TOO LOOSE
I'VE GOT THE RIGHT STUFF.
JUST RIGHT
I'LL NEVER BE THE SAME SHAPE AGAIN.
TOO MUCH!

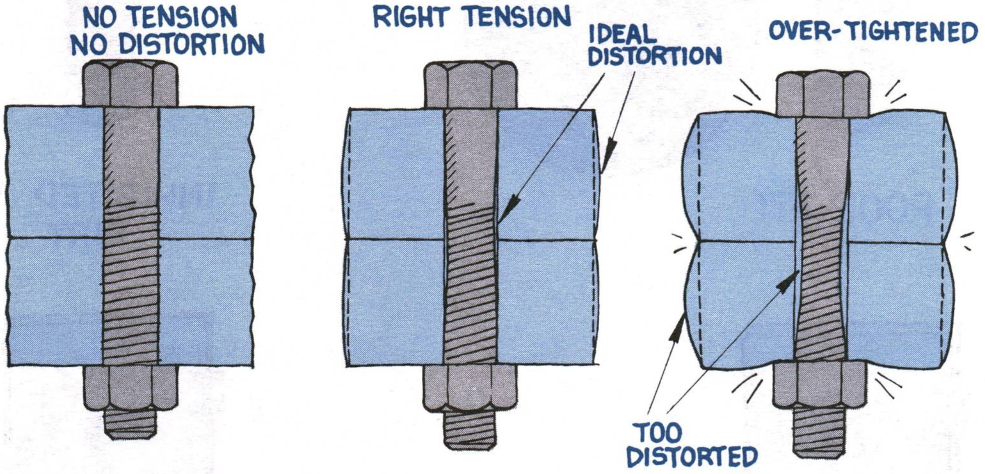
CLAMPING FORCE

The amount of pressure a bolt delivers when tightened is called clamping force. A properly tightened bolt provides the best clamping force or "load". Over or under-tightening decreases clamping force and causes the bolt to break under stress.

Two actions provide the force needed in a bolted joint. Bolt stretch is one aspect of the bolting process. Surface compression is the other aspect. During tightening, the bolt and surfaces act like springs. As load increases, the mating surfaces are brought into firm contact. The bolt "spring" stretches and the surface "spring" compresses. How well the surfaces join becomes very critical when exposed to conditions like changes in temperature, vibration, and the type of gasket material used.

When multiple bolts clamp two surfaces together, the method and amount of tightening becomes even more critical. The goal is to have each bolt apply the same amount of clamping force to the surfaces. The surface spring action causes the tension of one bolt to affect the tension of the other bolts. These joints rely on proper tightening to make them durable.





FACTORS AFFECTING CLAMPING FORCE

The factors that affect the clamping force of a fastener are:

- Fastener precision
- Fastener and surface cleanliness
- Lubrication

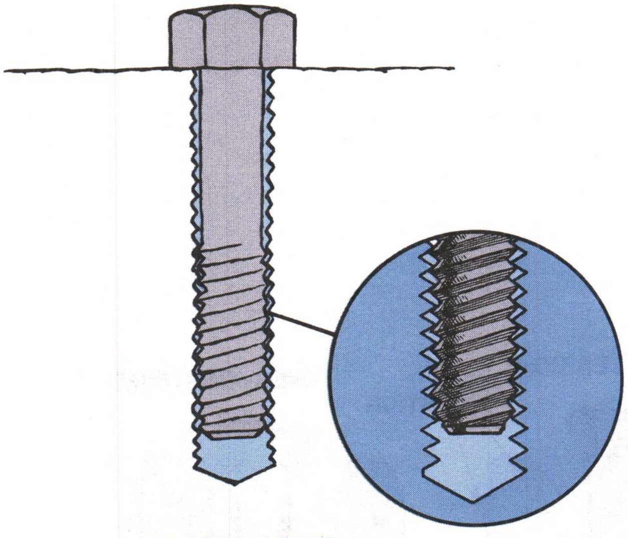
Fastener Precision

Fastener precision refers to the tolerance, method, and materials used in manufacturing. The closer these factors are controlled, the higher the quality of the fastener. These fasteners are uniform in size. Variation in size between bolts relates to how evenly the load can be distributed. The closer the bolts are in size, the more even the load distribution.

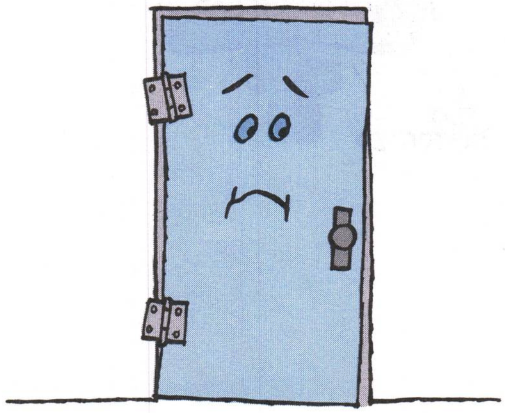
Fastener and Surface Cleanliness

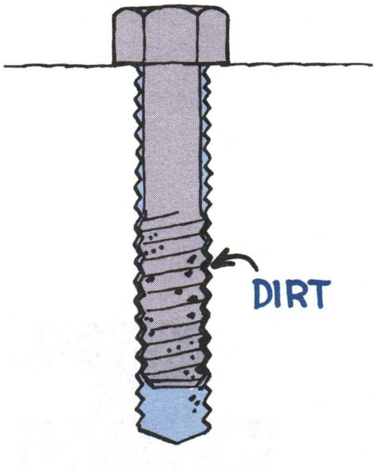
The bolt threads must be clean before assembly. Dirt on the thread surfaces adds friction to the tightening process. This reduces the amount of clamping force developed by the bolt during tightening. The bolt threads should be cleaned with a wire brush and the bolt hole should be cleaned with a tap. Feeling resistance while hand tightening a bolt shows that the threads need cleaning. An exception would be fasteners that use a locking feature such as deformed threads.

The surfaces being clamped together need to be clean and smooth. Any dirt or old gasket material must be removed before assembly. Dirt and old gasket material lessen the clamping force on the new gasket and cause a poor seal. Having to compress the contaminants uses some clamping force and reduces the force available for sealing.

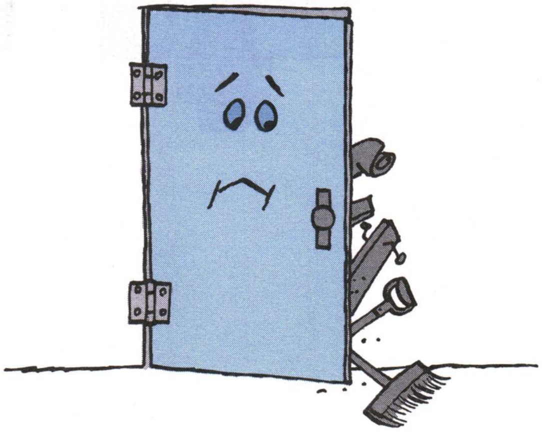


POOR FIT



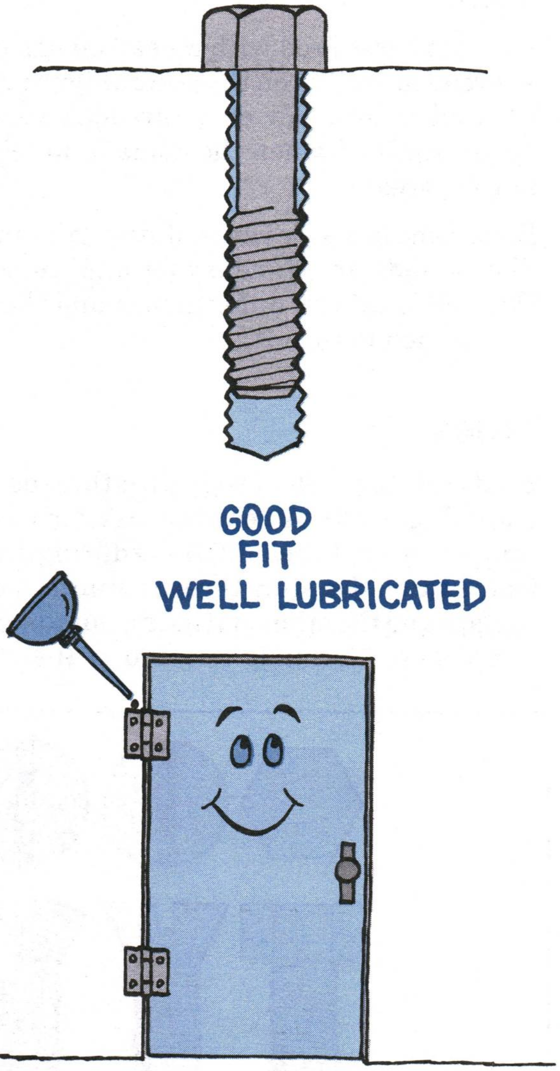


INHIBITED WITH DIRT



Thread Lubrication

Thread lubrication refers to the practice of adding a light film of engine oil to the bolt under-head and threads before assembly. Oil reduces the friction that occurs at the bolt threads during tightening. Some applications specify the use of a certain adhesive or lubricant instead of oil and some require the use of dry threads. Always consult the Shop Manual before assembly and use what is specified.



TYPES OF THREADED FASTENERS

MACHINE SCREWS

Machine screws are threaded fasteners less than 1/4 of an inch in diameter. They can be used with a nut or fit into a threaded hole. These screws fasten components that do not require much clamping force.

Machine screws come in many different shapes and sizes (Figure 1). Many machine screws are made for a particular application. The thread sizes are standard and the screw head can be specialized.

BOLTS

A bolt is a steel rod with a head on one end and a threaded section on the other (Figure 2). It can be used with a nut or a threaded hole. Bolts fasten surfaces when the demand for clamping force is great.

Bolts come in a wide range of strengths and sizes. The threads are standard for a given bolt size. The bolt head can differ in size and the type of tool needed to turn it.

STUDS

Studs consist of steel rods with threads on both ends (Figure 3). A common use for studs is a component that needs aligning during assembly. One end of the stud threads into a mounting surface and the other end uses a nut to secure the component. Normally one end of the stud has coarse threads and the other has fine threads. The nut works with the fine threads because they will loosen before the coarse threads. This allows the stud to remain in place during disassembly.

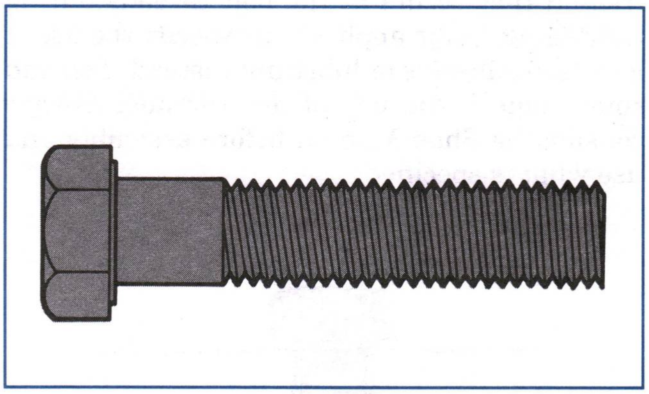


Figure 2. Bolt

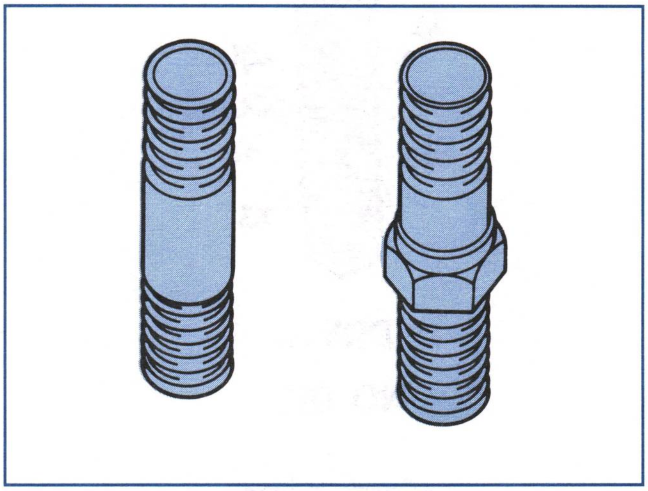


Figure 3. Studs

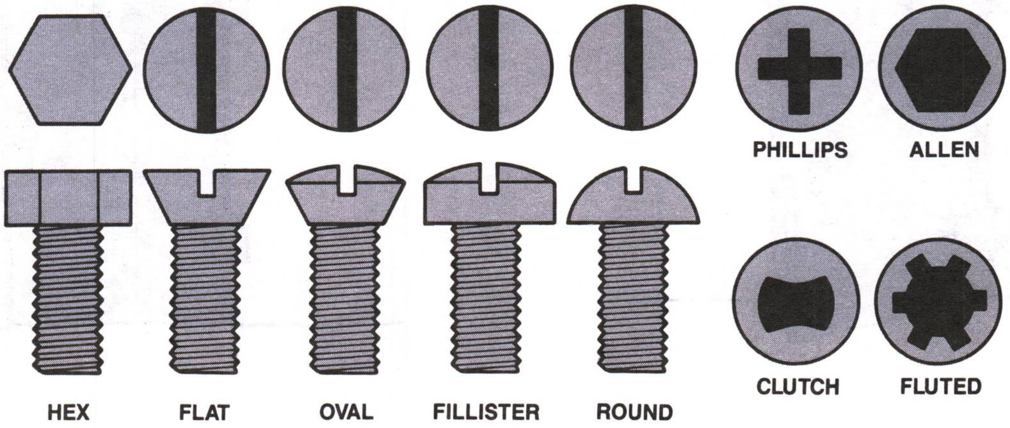


Figure 1. Machine Screws

BOLT IDENTIFICATION

PURPOSE OF IDENTIFICATION

Bolts can differ in strength, size and thread pattern. These factors determine the bolt used for a particular application. The ability to identify a bolt helps ensure that the replacement bolt matches the original bolt. Using a bolt that is the wrong length causes component damage or failure. Similar rules apply to the strength of a bolt. Using a bolt that is too weak can cause the bolt to break under stress. Using a bolt that is too strong does not cause a problem.

FASTENER LENGTH

Fastener length relates to two areas, the overall length and thread length (Figure 4). The overall length is measured from the bottom of the bolt head to the end of the threaded portion. Thread length is measured from where the threads begin on the shank to the end of the bolt. Both lengths must match the original bolt.

FASTENER STRENGTH

A bolt's strength varies with the materials and heat treatment used in manufacturing. Lower strength bolts consist of low-carbon mild steel and higher strength bolts have increased carbon content allowing for heat treating. The metal alloys added to the steel also affect bolt strength.

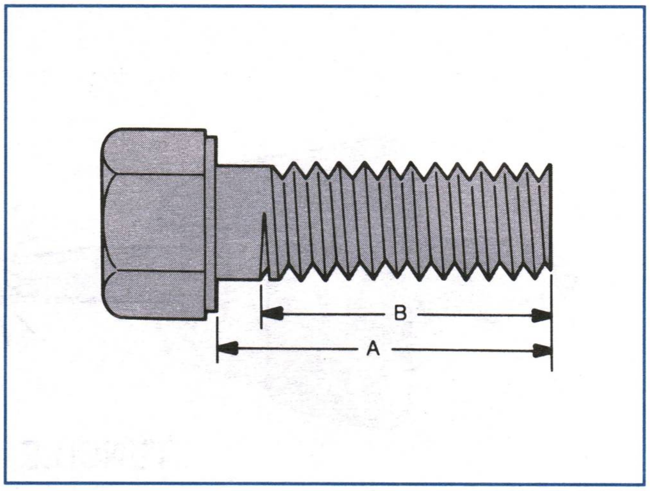
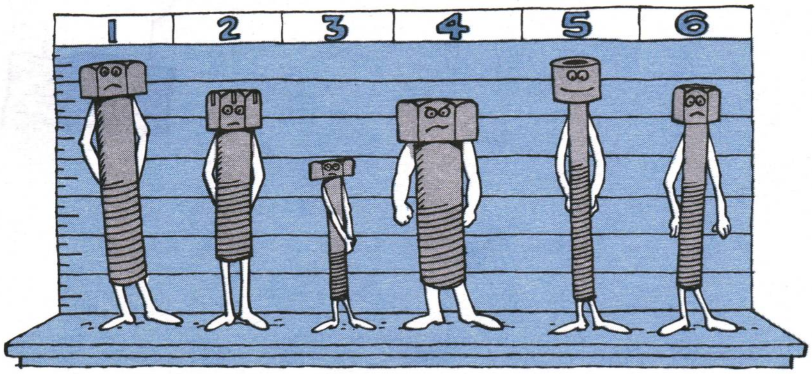


Figure 4. A. Overall Length
B. Thread Length



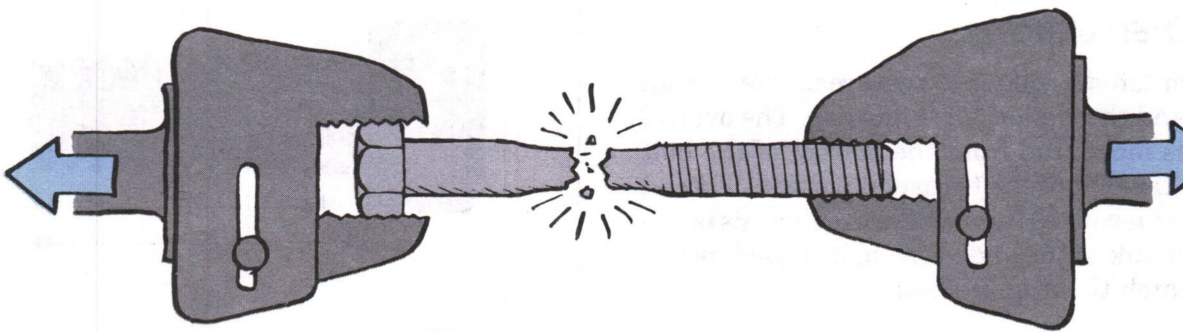
IDENTIFICATION OF BOLTS

BOLT IDENTIFICATION

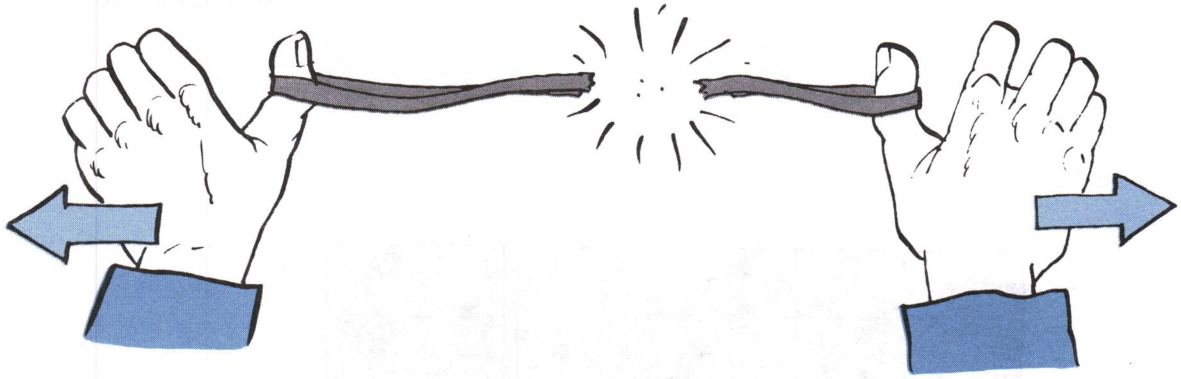
Tensile Strength

Tensile strength refers to the amount of force needed to break a material by pulling on it. This is the method used to rate the bolt material. A test machine pulls on a steel rod until it breaks and measures the amount of force it used. Tensile strength values are published in pounds per square inch.

Identifying fastener strength requires reading the value stamped into the bolt. The following systems allow for this identification process.



TENSILE STRENGTH



BOLT IDENTIFICATION

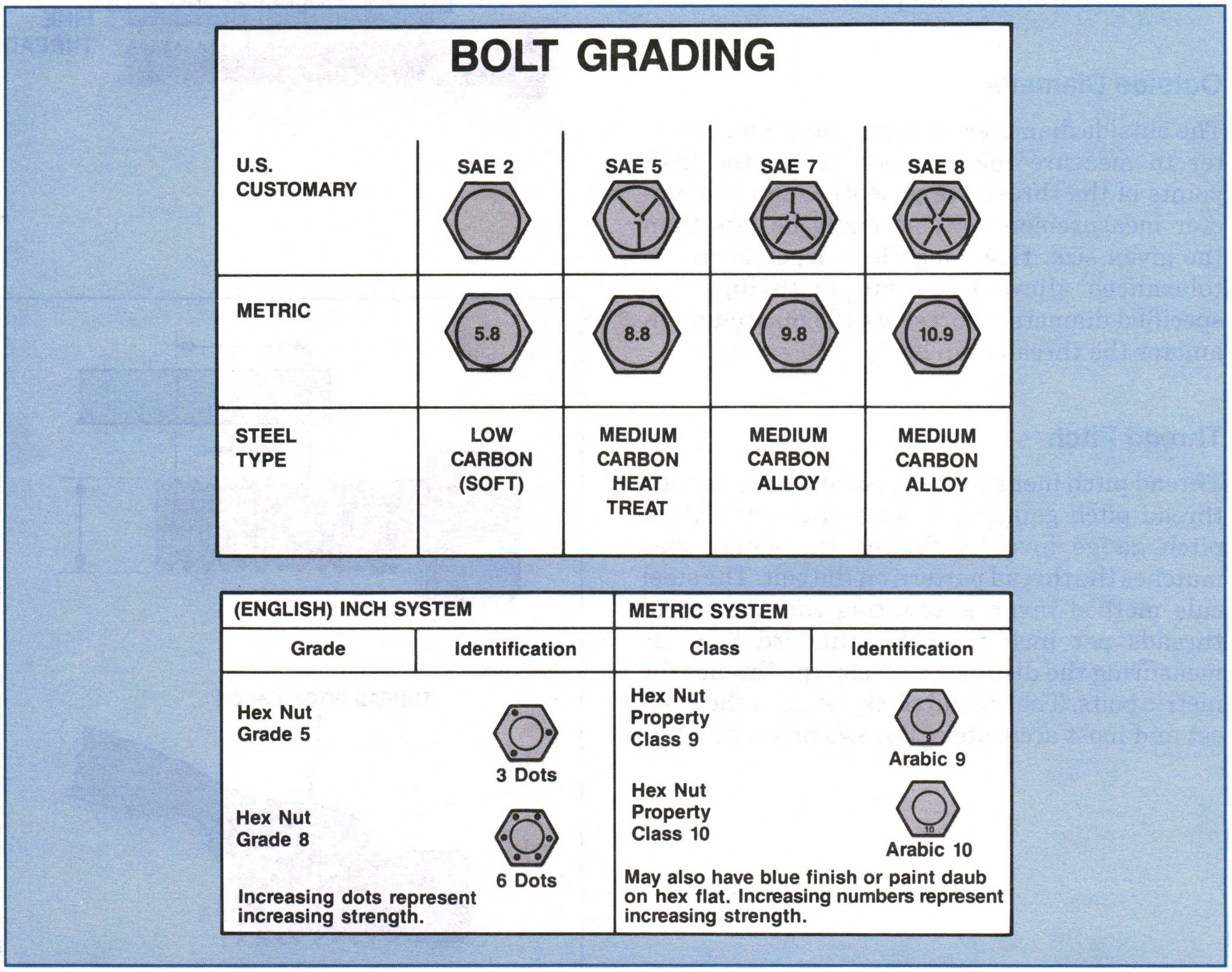
U.S. Standard Fasteners

The Society of Automotive Engineers (SAE) developed a system for grading the strength of U.S. standard bolts. The grade of a bolt relates to its strength. A code stamped into the bolt head identifies the grade. The number of marks stamped on the bolt head plus 2 identifies the SAE grade. If a bolt has three lines stamped on the head, the grade would be SAE 5. The more marks stamped on the bolt the greater the strength. The scale for SAE grading is 1 to 8 (Figure 5). Grade 1 is the weakest bolt and grade 8 is the strongest bolt.

Hex nut grading is identical to bolt grading. Marks stamped on the surface of the nut identify the grade. The nut and bolt grades must match to provide proper clamping force.

Metric Standard Fasteners

Metric standard bolt grade identification requires reading the number stamped on the bolt head or nut surface. The number relates to the strength of the bolt. The higher the number is, the stronger the bolt. Metric ratings of 4.6, 5.8, 8.8, 9.8 and 10.9 are common to automotive applications. The 4.6 rating compares to an SAE grade 1 and the 10.9 rating compares to an SAE grade 8.



BOLT GRADING

U.S. CUSTOMARY	SAE 2	SAE 5	SAE 7	SAE 8
METRIC	5.8	8.8	9.8	10.9
STEEL TYPE	LOW CARBON (SOFT)	MEDIUM CARBON HEAT TREAT	MEDIUM CARBON ALLOY	MEDIUM CARBON ALLOY

(ENGLISH) INCH SYSTEM		METRIC SYSTEM	
Grade	Identification	Class	Identification
Hex Nut Grade 5	3 Dots	Hex Nut Property Class 9	Arabic 9
Hex Nut Grade 8	6 Dots	Hex Nut Property Class 10	Arabic 10
Increasing dots represent increasing strength.		May also have blue finish or paint daub on hex flat. Increasing numbers represent increasing strength.	

Figure 5. Bolt Grading

BOLT IDENTIFICATION

THREAD IDENTIFICATION

Bolt threads can either be "coarse" or "fine". The distance between the threads determines this. Coarse threads are farther apart than fine threads. The type of thread used also affects bolt strength.

Bolt threads are external threads and threaded hole or nut threads are internal threads. External threads are weaker when they are coarse and internal threads are stronger when they are coarse. Engine block threaded holes have coarse threads so a fastener related problem will cause the bolt to fail instead of damaging the engine block.

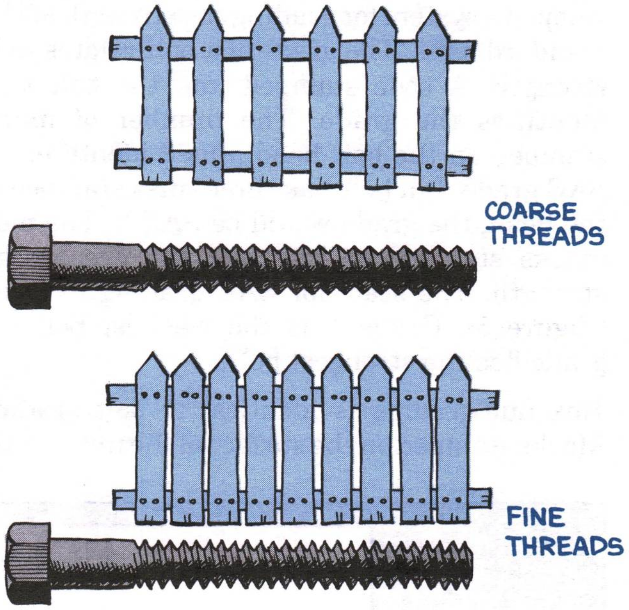
Identifying threads involves measuring the outside diameter and thread pitch.

Outside Diameter

The outside diameter requires using a micrometer to measure the distance across the high points of the threads (Figure 6). Outside diameter measurement will normally be less than the given size. How much less depends on the tolerances allowed in manufacturing. The specified diameter represents the maximum diameter the threads can be.

Thread Pitch

Thread pitch measurement requires the use of a thread pitch gauge or a steel rule. The thread pitch gauge involves finding the gauge that matches the thread pattern on the bolt. The steel rule method involves counting the number of threads per inch for U.S. standard bolts or measuring the distance between the threads for metric bolts. The thread pitch gauge is the easiest and most accurate of the two methods.



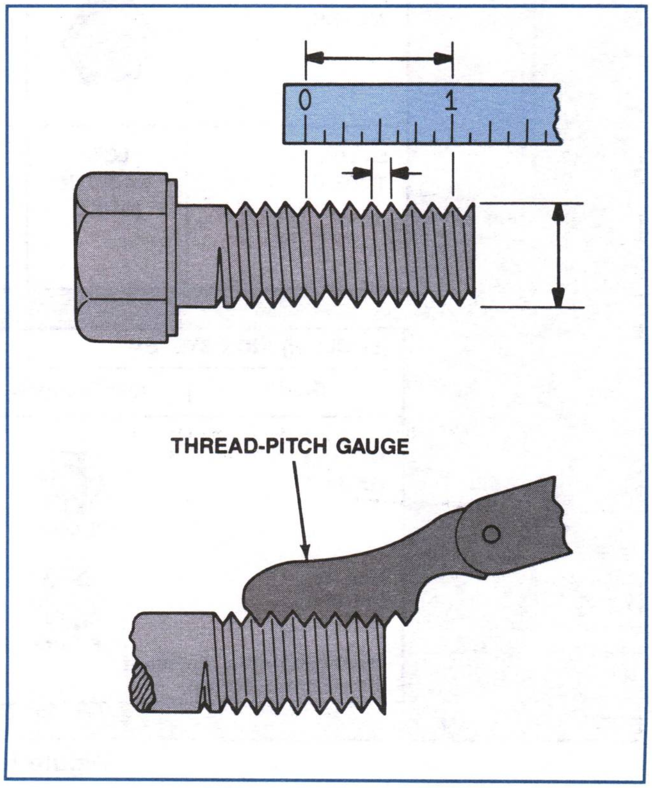
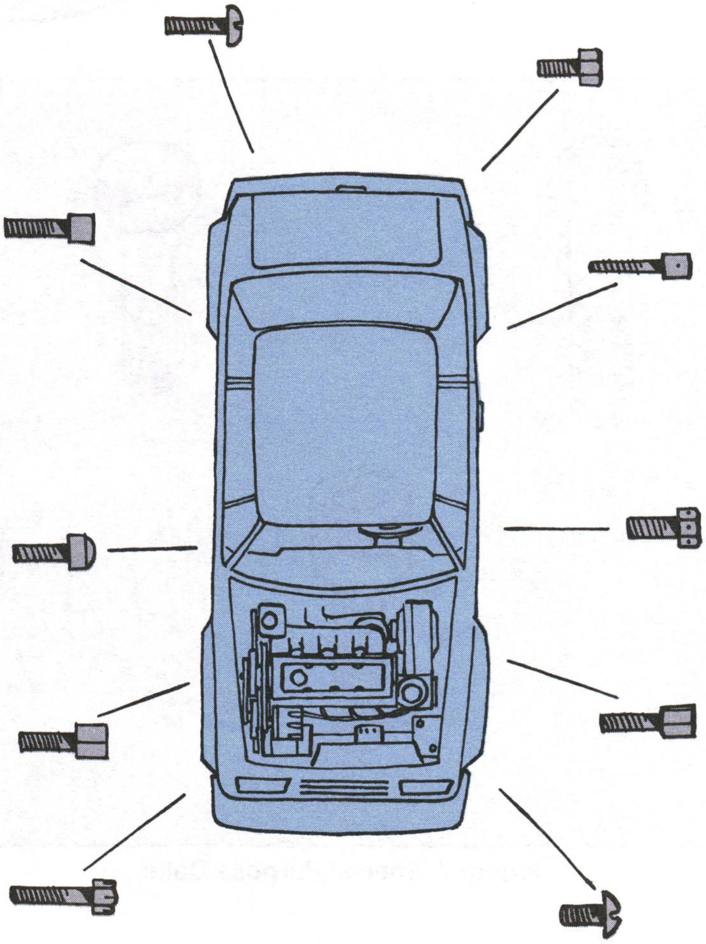


Figure 6. Measuring Thread Pitch

BOLT SPECIALIZATION

Some fasteners used in automobile engines today are designed for a specific application. Unlike standard fasteners, these bolts meet the needs of a certain component. These fasteners allow less tolerance in manufacturing and can only be purchased through certain suppliers.



An example of this would be the bolts that have an integral washer in the bolt head (Figure 7). The integral washer allows the load to be distributed over a larger surface area than the bolt head normally would. The type of surface used determines the washer size. A washer that is too small causes the bolt head to sink into the surface as it tightens. In the past, bolts like these had a standard integral washer size that may or may not have been large enough to support the load. Today, more attention goes into determining the washer size. Because of this, the bolt is considered a specific part rather than a general fastener.

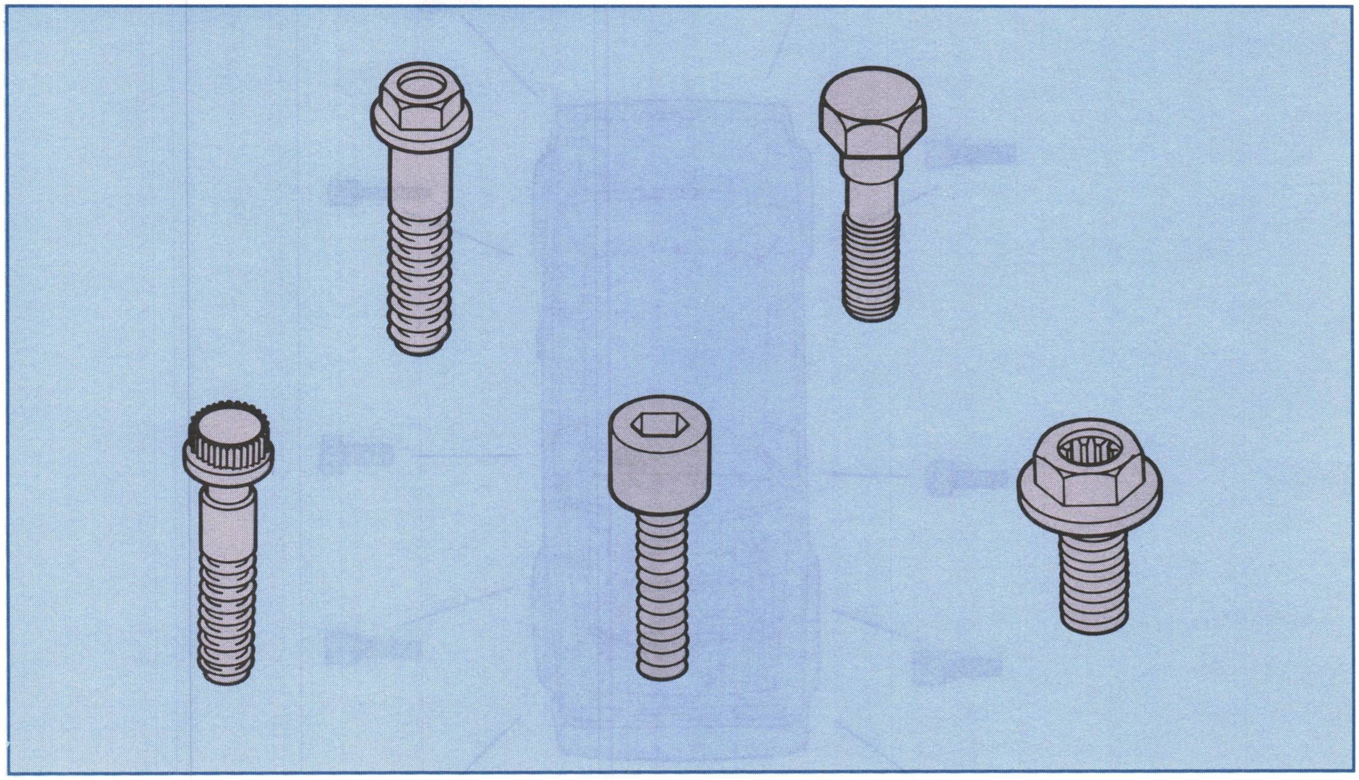
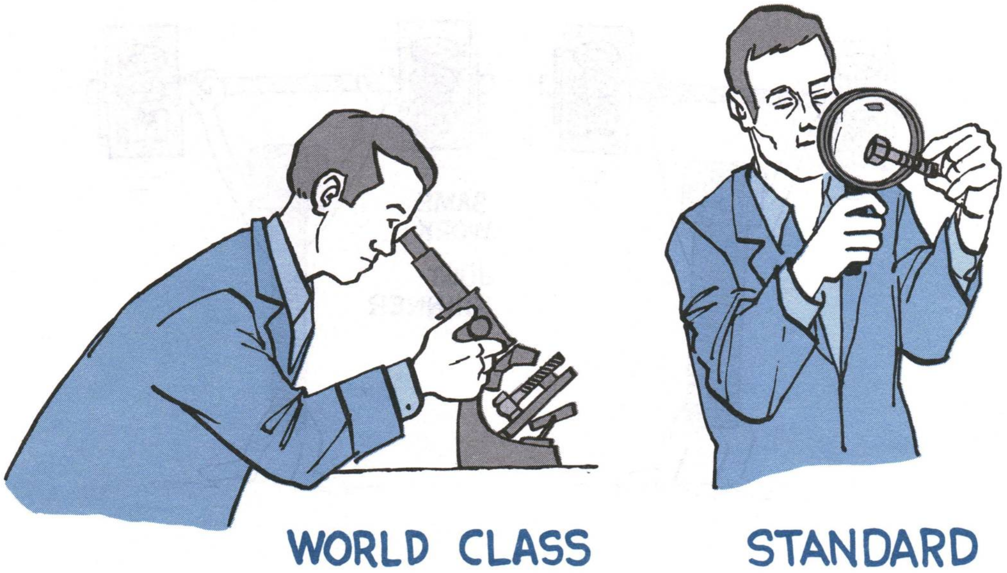


Figure 7. Special Purpose Bolts

BOLT IDENTIFICATION

World Class Quality Bolts

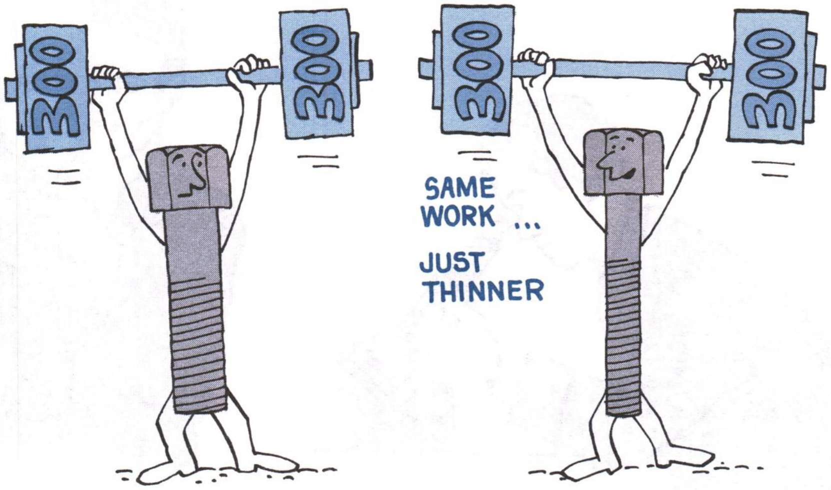
World class quality bolts refer to bolts manufactured under stricter guidelines than standard bolts. More attention to the method, level of control and materials used in manufacturing make these bolts uniform in size. Less tolerance in thread diameter and pitch make these bolts more of a precision fastener. These bolts allow for more consistency when using multiple bolts to clamp two surfaces.



Torque to Yield Bolts

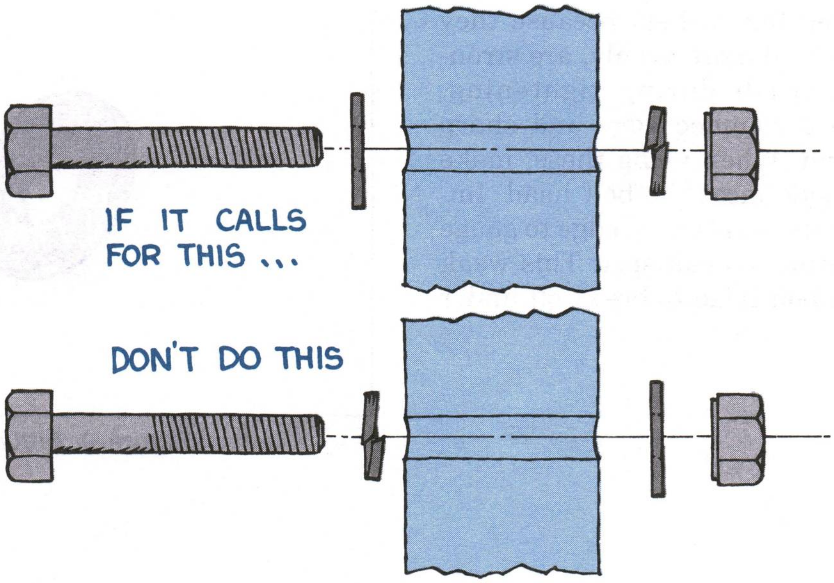
Torque to yield refers to bolts designed to be stretched to the "yield point". The yield point is where a bolt gives the greatest amount of clamping force. At this point the threads become permanently distorted from being stretched to the limit. Using these bolts a second time increases the chance of breaking due to fatigue.

Torque to yield bolts are manufactured to world class quality standards to ensure uniform clamping force. These bolts help in areas where component size reduction is desired. Smaller bolts can do the same work that larger bolts used to do. The size of the bolt needed determines the size of the component. The use of smaller bolts allows for smaller component size.



PROPER FASTENER USE

Fasteners serve many different purposes and various devices help them provide proper clamping force. The addition of hex nuts, flatwashers, locknuts and lockwashers allow fasteners to work in the different areas. These devices can present certain problems when used incorrectly. Care should be taken to install them properly. Failure to do so can result in fastener failure.



PROPER FASTENER USE

HEX NUTS

Hex nuts (Figure 8) are used when the bolt penetrates the clamping surfaces. The hex nut and the bolt must be the same grade and have the same thread pattern.

NOTE: Using nuts and bolts of different grades will not allow for proper clamping force to be developed.

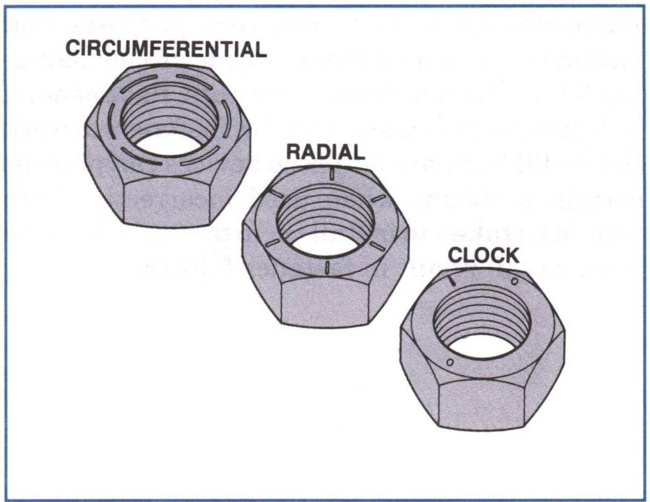


Figure 8. Hex Nuts

FLATWASHERS

Flatwashers (Figure 9) distribute the bolt load over a larger surface area. This protects the surface from being damaged by the bolt. They do not prevent the bolt from coming loose. There are two types of flatwashers available, machined and stamped. Machined flatwashers are superior to stamped flatwashers because they tend to spread the load more evenly, are stronger, and do not crush during tightening. Flatwashers have a rounded edge and sharp edged sides to them. When using these, make sure the rounded side faces the bolt head. Improper assembly causes the sharp edge to gouge the bolt head creating a weak spot. This weak spot can cause the bolt head to break off under stress.

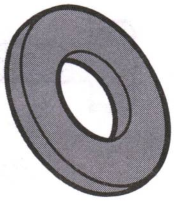


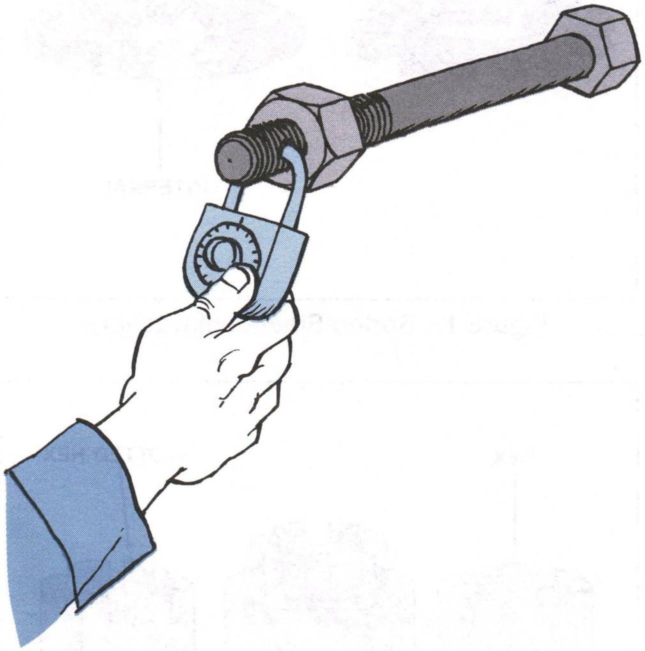
Figure 9. Flatwasher

MECHANICAL LOCKING DEVICES

Mechanical locking devices help keep fasteners tight on some applications. These include lockwashers, locknuts, cotter pins, locking tabs and safety wire. Locking devices help in areas where the fastener encounters varying loads and vibration or the fastener can pose a safety concern if it loosens.

COTTER PINS, LOCKING TABS, SAFETY WIRE

Cotter pins, locking tabs and safety wire (Figure 10) do not add tension to the fastener. They prevent a fastener from coming loose by not allowing it to turn. These devices work in areas where a loose fastener can cause a safety concern. The only way the fastener can loosen is if these shear, break or fall off.



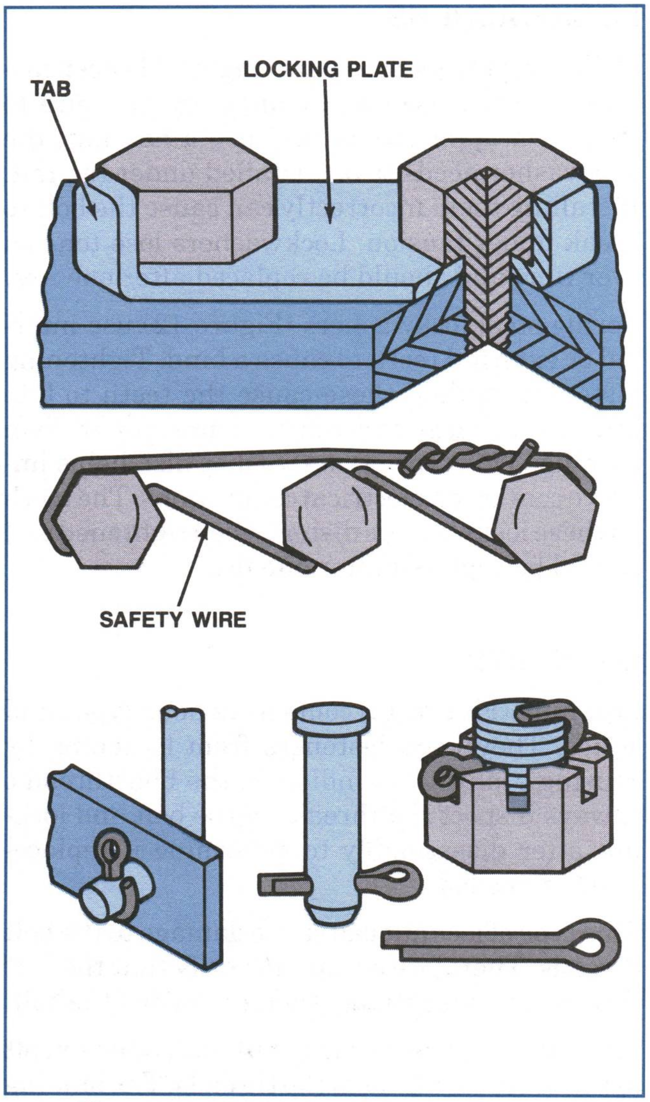


Figure 10. Mechanical Locking Devices

MECHANICAL LOCKING DEVICES

LOCKWASHERS

Helical spring lockwashers (Figure 11) keep fasteners from loosening by applying pressure to them. On applications that use a hex nut, the lockwasher needs to be installed under the nut. Installing them incorrectly can cause the bolt to break under tension. Lockwashers lose tension over time and should be replaced after one use.

Spring steel lockwashers (Figure 12) use internal or external teeth to cause a bind. Tightening fasteners against these cause the teeth to bite into the surface and nut and prevent it from turning. This type of lockwasher also helps improve contact on electrical connections. The teeth on these lockwashers distort when tightened and should be replaced after one use.

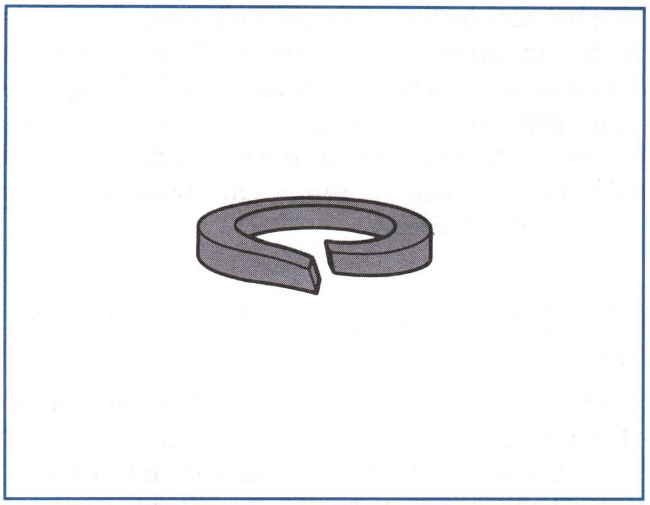


Figure 11. Helical Spring Lockwasher

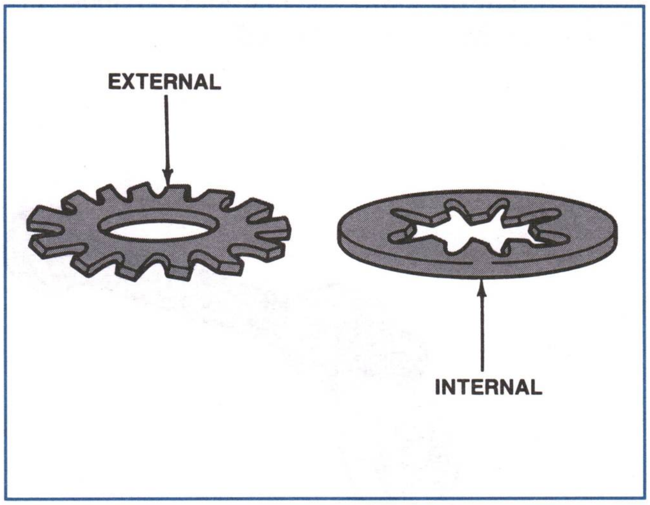


Figure 12. Spring Steel Lockwashers

LOCKNUTS

Locknuts (Figure 13) come in various types and styles. They keep fasteners from loosening by causing a physical binding in the bolt threads. Always inspect the threads of the bolt and locknut after disassembly to determine if replacement is needed.

This type of locknut can cause damage to the bolt threads. Therefore be sure to verify that the bolt threads are not damaged before reusing the bolt.

The collar type uses a ring of plastic, fiber, or soft metal to create a bind in the threads. The binding action occurs when the collar forms to the bolt threads during tightening. This type of locknut works in areas where the temperature will remain somewhat cool.

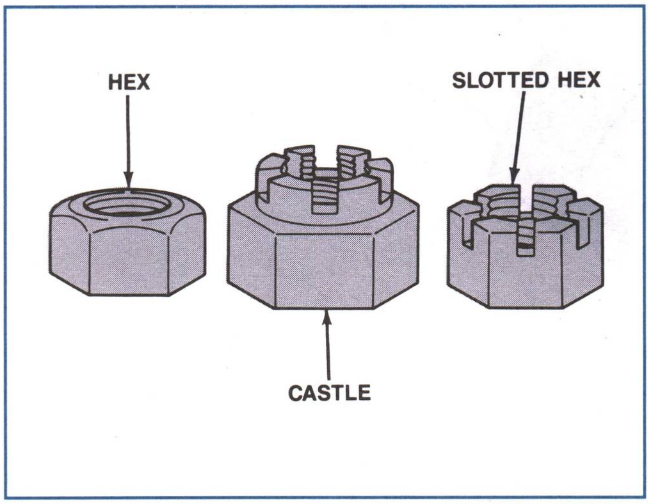


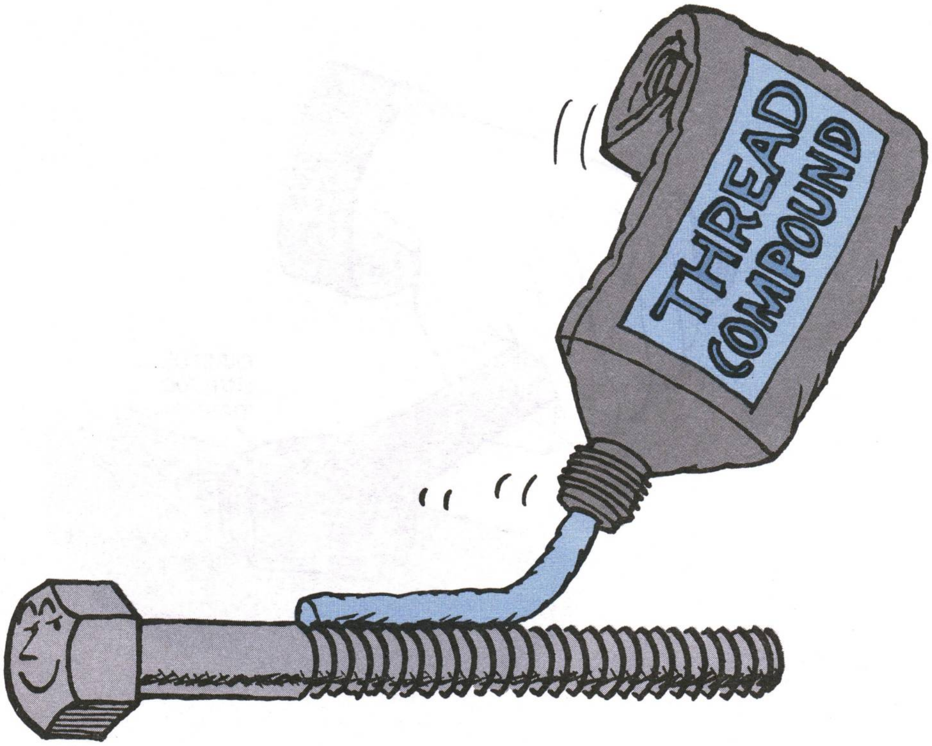
Figure 13. Locknuts

THREAD COMPOUNDS

Some fastener applications require the use of thread compounds to keep them from loosening. These compounds take up the space between the threads after tightening and harden to form a bond between the internal and external threads.

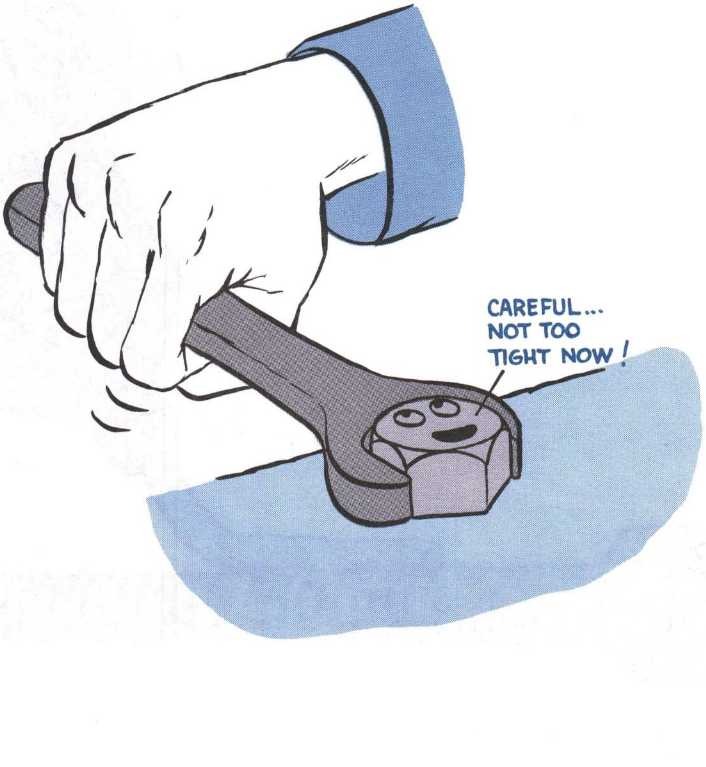
Thread compounds come in a variety of applications. The differences between the compounds relate to the temperature range it can withstand and the type of metal it works with. These compounds should only be used when specified by the Shop Manual. In those cases, only use the type specified. The trend on newer engines is to either assemble the bolts dry or use a light film of oil on the threads and bolt head.

Some fasteners require using anti-seize compound on the threads. When the fastener threads into an aluminum component or the temperature will be high, anti-seize is recommended. This helps ensure that the bolts will loosen when disassembling the component.



TORQUE

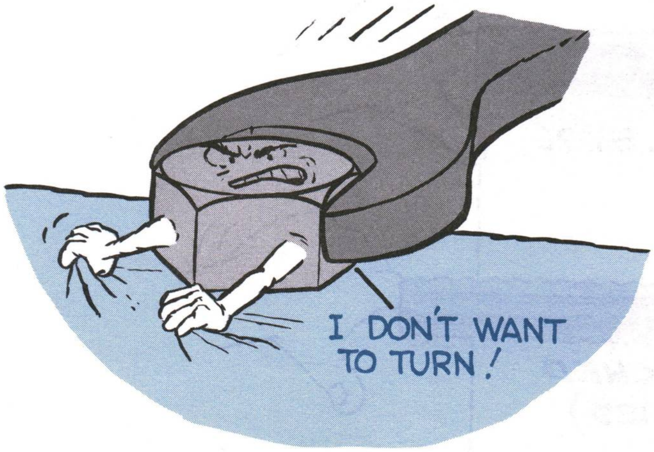
Torque refers to the amount of twisting force applied to a fastener during tightening. The ability to measure torque allows the fastener to be tightened properly. Fasteners provide a certain amount of clamping force if they are torqued a specific amount. Always consult the appropriate service manual before repairing a vehicle. Each fastener has a specified torque value that should be used. Standard torque tables provide general torque information for various bolt sizes, but these should be used as a last resort.

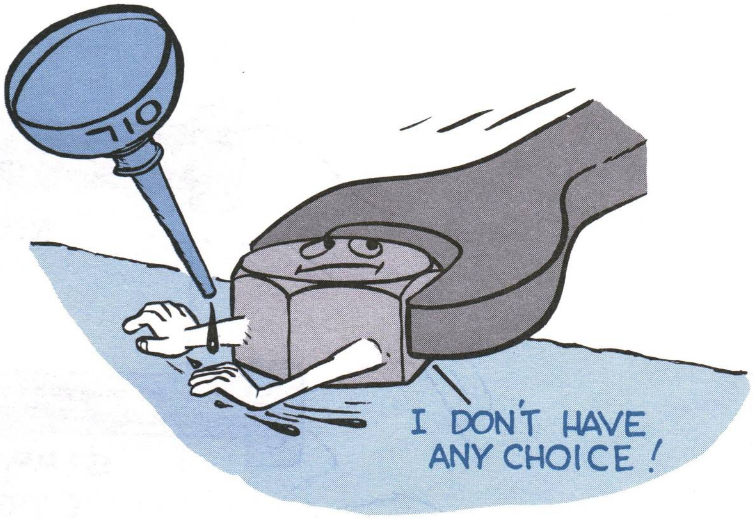

CAREFUL...
NOT TOO
TIGHT NOW!

CONCEPTS OF TORQUE

BOLT FRICTION

Friction causes many problems when torquing bolts. Bolt tension and friction use the energy from torque. Bolt tension uses up 10% of the energy and friction (heat) uses up 90% of the energy. Bolt tension is the desired result from torque. Friction takes the energy away from the bolt tension. Friction during tightening relates to two different areas: contact between the internal and external threads and between the bolt head and the surface. Friction can be reduced in these areas by applying a light film of engine oil to the bolt head and threads before assembly. Consult the Shop Manual before using oil because some applications require other substances or the bolt needs to be dry.


I DON'T WANT TO TURN!

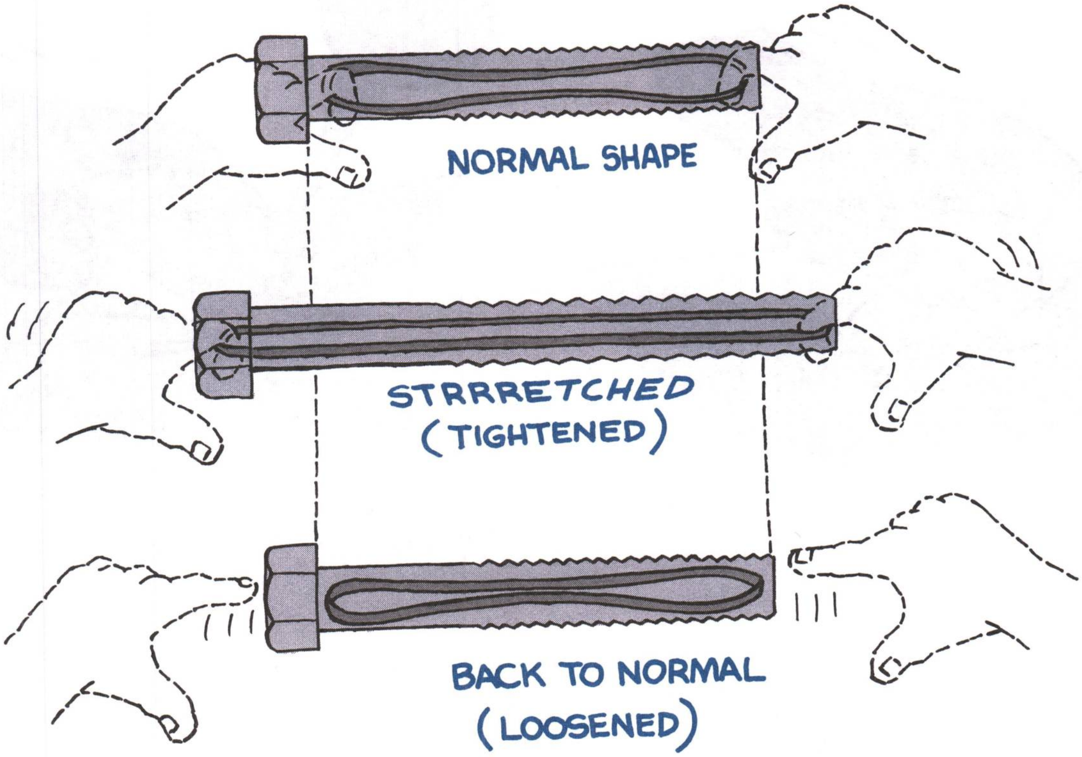

OIL
I DON'T HAVE ANY CHOICE!

ELASTIC LIMIT

The reactions of the bolt and the surfaces are key factors in providing a strong joint and seal. Hand tightening a bolt causes no change in either the bolt or the surfaces. Further tightening causes the bolt threads to stretch and the surfaces to compress. Both the bolt and the surfaces have an "elastic limit". This refers to a metal's ability to stretch under tension and return to its original shape and size.

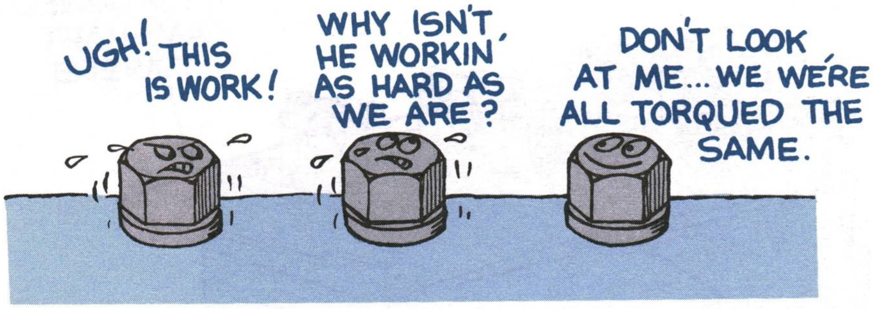
Hooke's law simply states that if a material stretches within its elastic limit, it will return to its original size after removing the tension. Stretching a material past the elastic limit causes it to weaken and retain some stretched shape.

In fastener applications, stretching the bolt within its elastic limit gives the most force possible. The torque value specified for a fastener keeps it within the limit. Ignoring torque specifications removes any chance of ensuring that the part fastens correctly.



MULTIPLE FASTENERS

The use of torque gets complicated when multiple fasteners hold two surfaces together. During tightening, the surfaces move as the pressure increases. Tightening one bolt causes the tension from the other bolts to change. Tightening all the bolts the same amount still causes the load from each bolt to be different. Even after using the proper torque methods there can be a 50% variation in the loads applied. The variation when tightening the bolts by feel will be drastic.


UGH! THIS IS WORK!
WHY ISN'T HE WORKIN' AS HARD AS WE ARE?
DON'T LOOK AT ME... WE WE'RE ALL TORQUED THE SAME.

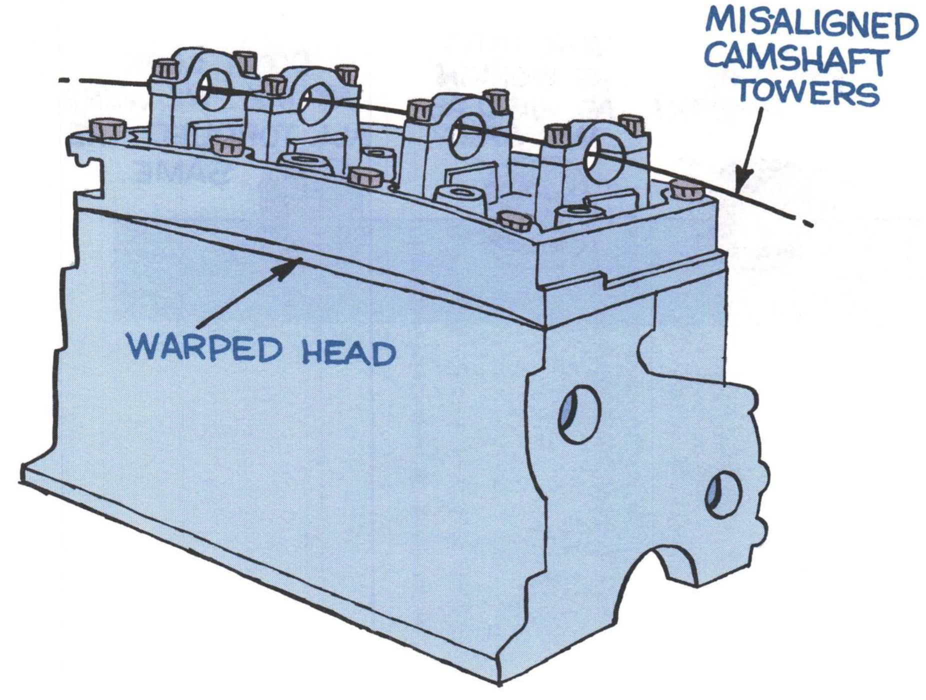
EFFECTS OF FASTENER TORQUE ON ENGINE COMPONENTS

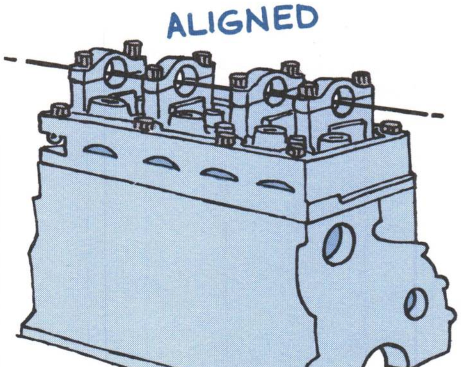
CYLINDER HEAD

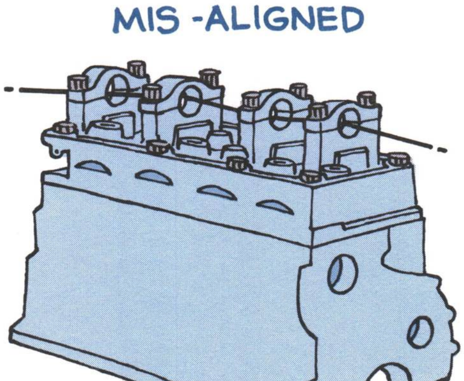
Improper torque methods can damage the cylinder head and head gasket. The cylinder head must be disassembled and assembled correctly or the head will warp. A warped cylinder head cannot seal properly and must be machined or replaced once this damage occurs.

OVERHEAD CAMSHAFT

Incorrect torque methods can damage the camshaft and cylinder head on engines with an overhead camshaft. The caps that secure the camshaft must be disassembled and assembled in a specific order. The camshaft is under constant tension from the valve springs and loosening the bolts in the wrong order can distort the towers that support the camshaft. During assembly, the caps for the camshaft tend to twist as they tighten. Torquing the bolts in the wrong order or over-tightening can cause the caps to crack or distort the alignment of the towers, which causes rapid wear of the camshaft and bearings.





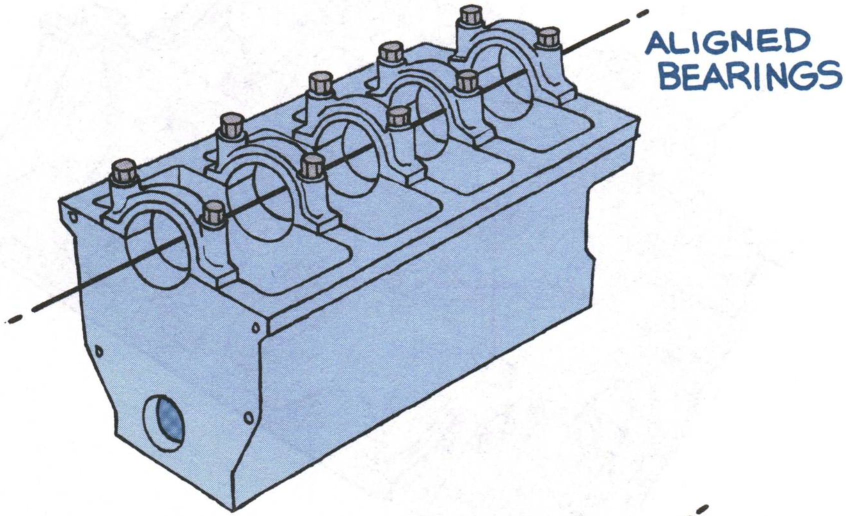


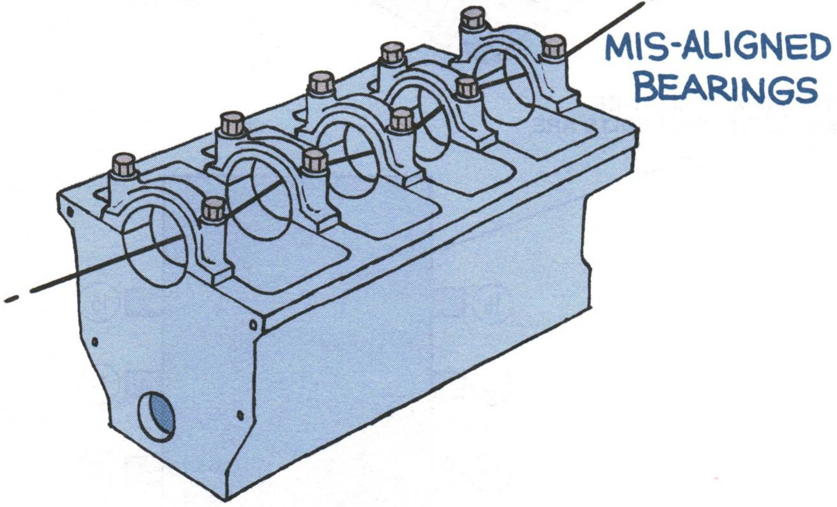
EFFECTS OF FASTENER TORQUE ON ENGINE COMPONENTS

MAIN BEARING CAPS

Main bearing caps need to be assembled properly for correct crankshaft operation. When removing main bearing caps, be sure to mark each one so it can be re-installed in the same position. Failure to do this can result in the cap cracking from uneven stress at the mating surfaces.

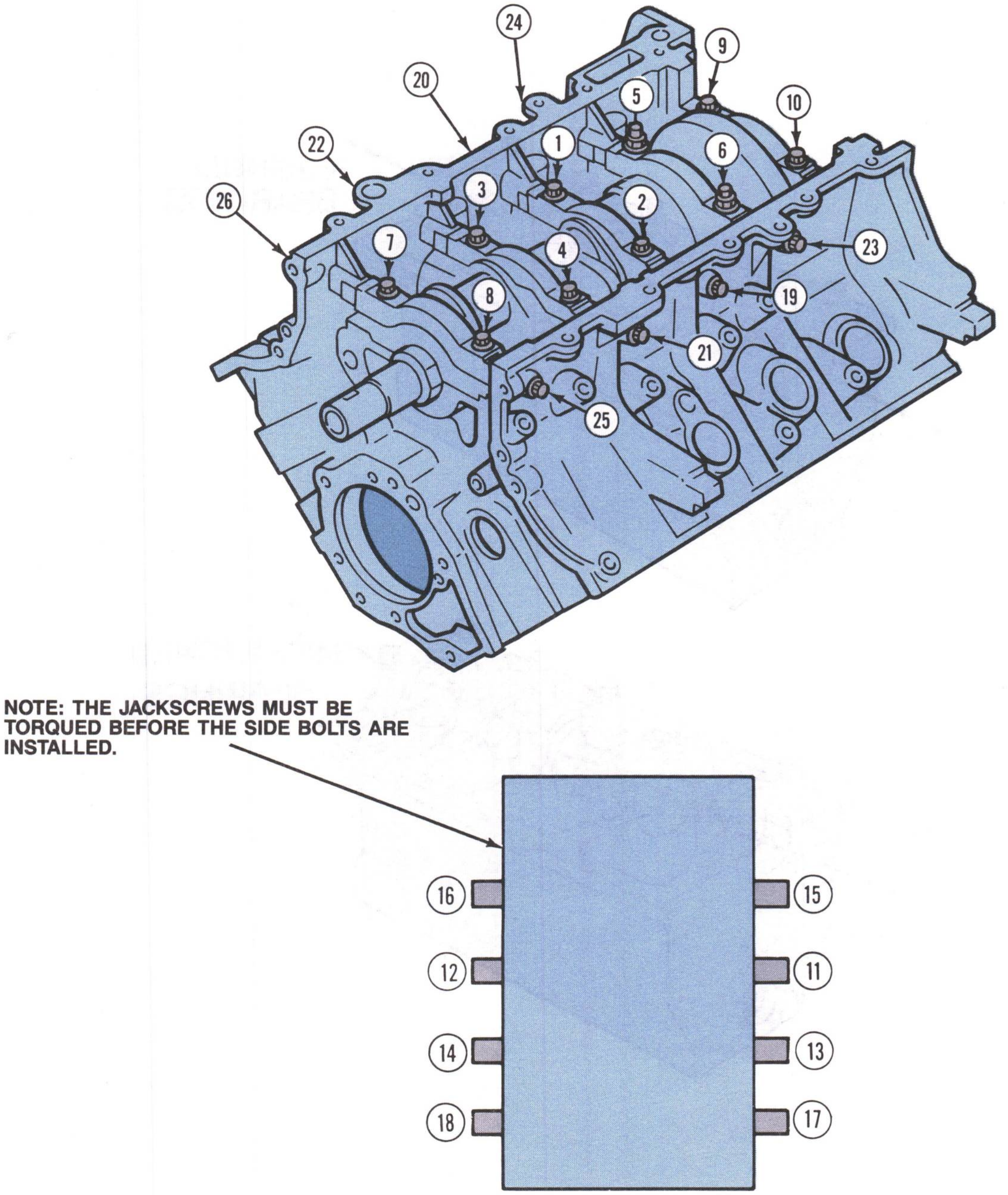
During assembly, the main bearing caps have a tendency to twist from the bolt stress. If the twist becomes too great the cap will break or the crankshaft will not turn. Proper torquing eases the stress on the caps and reduces the twisting action.





EFFECTS OF FASTENER TORQUE ON ENGINE COMPONENTS

The 4.6L engine uses jackscrews and side bolts to keep the main bearing caps from twisting too much. The methods for disassembly and assembly must be followed to ensure proper crankshaft operation (Figure 14). Failure to follow these procedures can result in the crankshaft not turning and rapid main bearing wear.



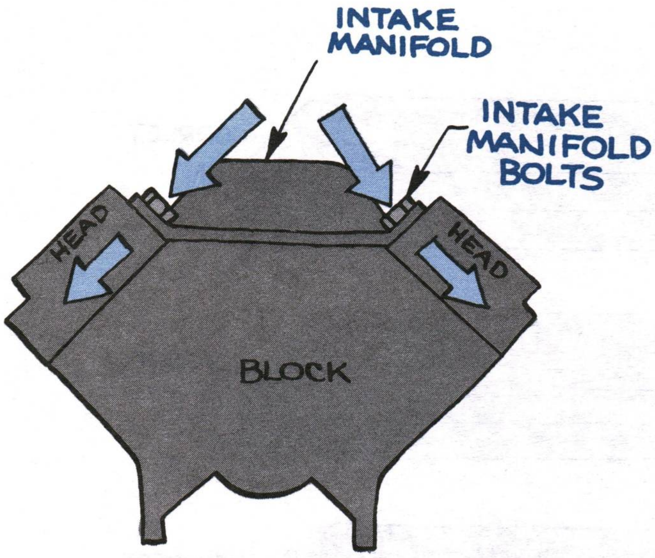
NOTE: THE JACKSCREWS MUST BE TORQUED BEFORE THE SIDE BOLTS ARE INSTALLED.

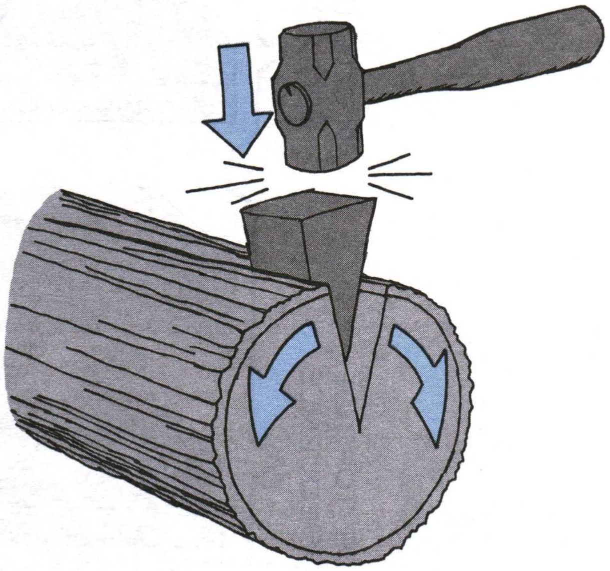
Figure 14. 4.6L Main Bearing Cap, Jackscrew and Sidescrews Torque Sequence

EFFECTS OF FASTENER TORQUE ON ENGINE COMPONENTS

INTAKE MANIFOLD

Improper assembly and disassembly of the intake manifold can damage it and other components. Intake manifolds on most V-block engines have angled surfaces that mount to the cylinder heads. During assembly the angled surfaces cause a different type of reaction. The angle of the surface pushes outward on the cylinder head as the surfaces clamp together. This stress can distort the cylinder head and twist the engine block. This twisting of the engine block changes the shape of the cylinder bores and causes excessive engine wear and premature engine failure.

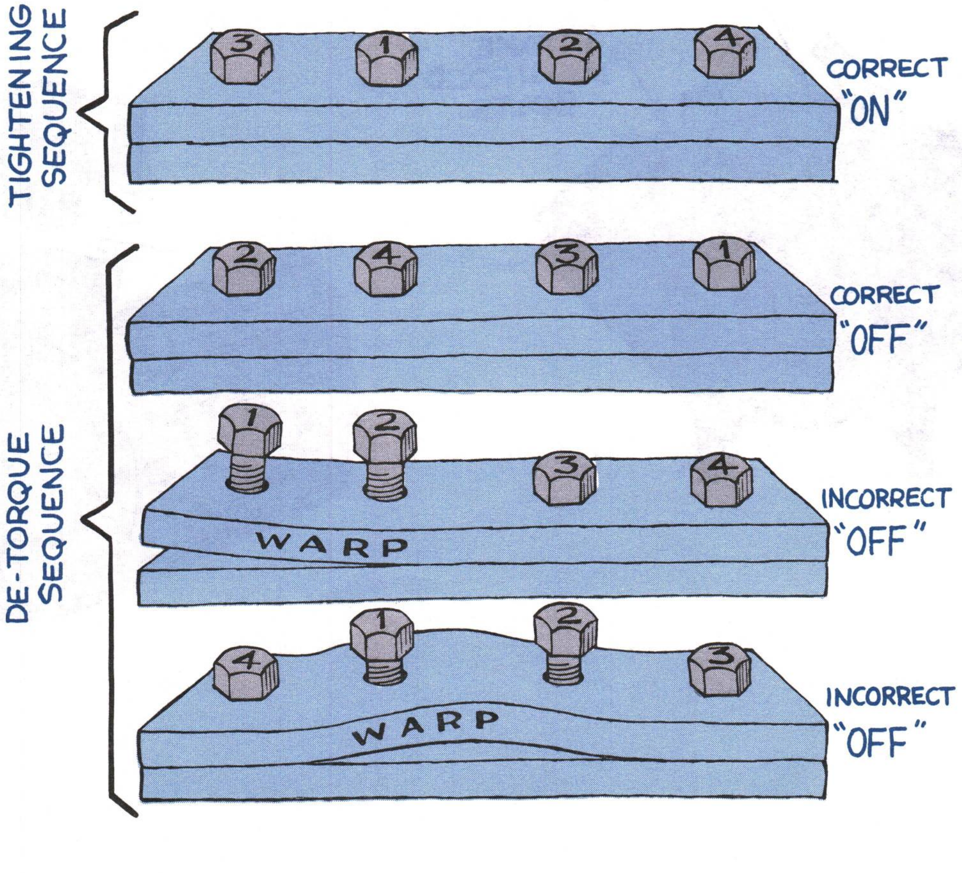




DE-TORQUE PROCEDURE

REASONS FOR DE-TORQUE

De-torque refers to the method for removing a component that uses multiple fasteners. A specific order must be followed when loosening the bolts on these applications (Figure 15). The clamped surfaces are under tension and loosening the bolts relieves the tension. De-torque allows the surfaces to relax at an even rate and prevents the component from distorting or cracking. This should be done after the component has cooled. Heat increases the tension of the surfaces and makes it hard to control the rate at which it relaxes.



DE-TORQUE PROCEDURE

DE-TORQUE SEQUENCE

The Shop Manual may supply a specific de-torque sequence for the component. For components that do not have a specific de-torque sequence, reverse the tightening sequence. The method for de-torque is to break the bolts loose in sequence unless the Shop Manual specifies differently.

NOTE: A torque wrench should not be used for de-torque. The torque needed to loosen the bolts may exceed the limits of the wrench and damage its accuracy.

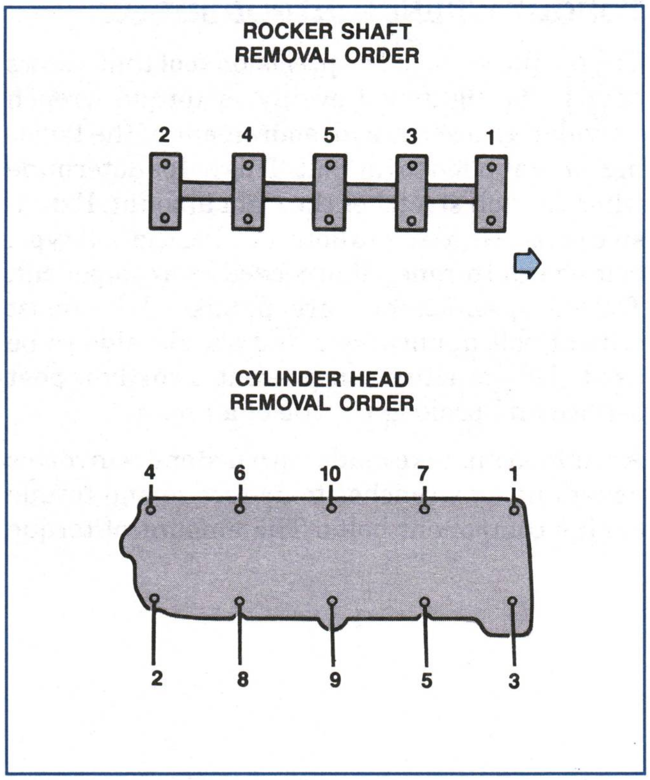


Figure 15. Sample De-torque Sequence

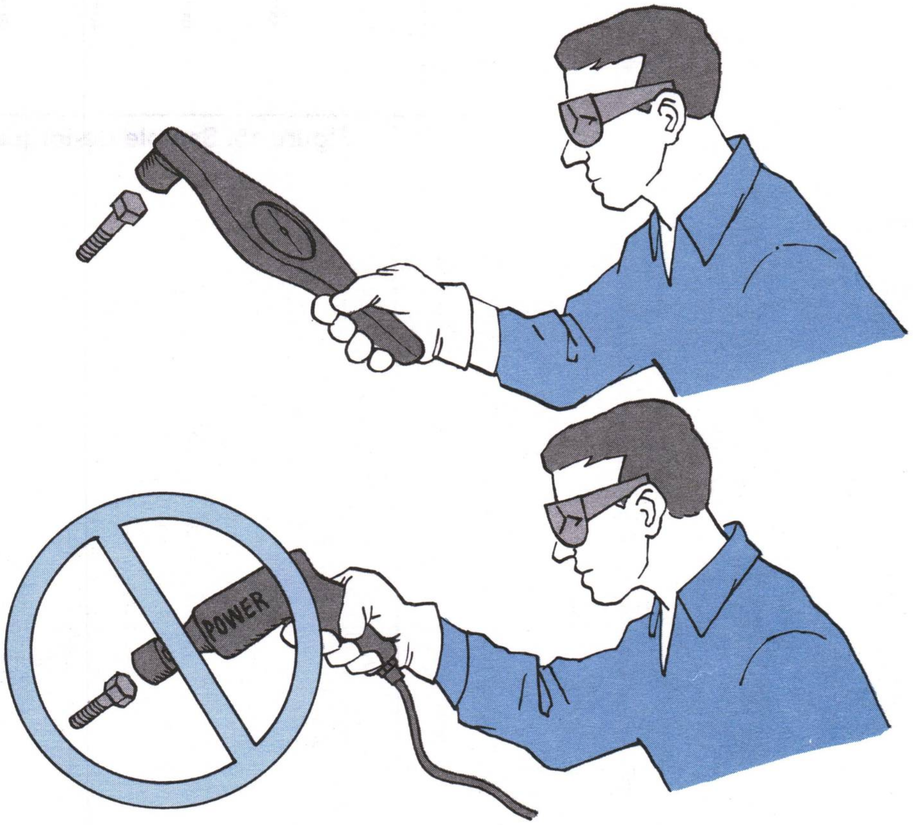
USING A TORQUE WRENCH

TORQUE WRENCH INTRODUCTION

The torque wrench is a precision tool that allows bolts to be tightened evenly. A torque wrench provides an accurate measurement of the twisting force applied to the bolt. This helps determine when the bolt stretches the right amount. Extensive research goes into determining the bolt type, bolt size and torque value needed for a component. Torque specifications are published for most critical bolt applications and should always be used. This practice can prevent a costly repeat service and prolong the life of a repair.

A common mistake made with fasteners involves using impact wrenches to de-torque and torque engine component bolts. The amount of torque an impact wrench delivers is difficult to figure out. Tightening a fastener requires a steady turning motion. Impact wrenches apply torque with a hammer-like motion. The amount of force applied to the bolt will not be accurate because of this motion. Air wrenches must be avoided when working on engine related repairs. Using an impact wrench to de-torque bolts causes the same problem. The torque cannot be controlled properly so the surface relaxation cannot be controlled.

CAUTION: Do not use an impact wrench to loosen or tighten engine bolts.



USING A TORQUE WRENCH

TYPES OF TORQUE WRENCHES

Torque wrenches come in various types and sizes that measure inch-ounces, inch-pounds and foot-pounds. They also come in English, metric, and Newton-meter calibrations. Some use a scale that allows the torque value to be read during tightening and some only show when it reaches a preset torque value.

Beam Type Torque Wrench

A beam type torque wrench uses a flexible alloy steel beam that deflects during tightening (Figure 16). A pointer attached to the end of the beam shows the torque value on a scale. The advantage of this type is the simple design. Very little can go wrong with it. The drawback is that this wrench is not as accurate as others.

Click Type Torque Wrench

A sensory or click type torque wrench uses an audible click to indicate when it reaches a preset torque value (Figure 17). This type has a dial on the handle to set the torque specification for the bolt. The advantage of this type is that it can be used in hard to reach areas where a scale would be hard to read. The drawback is that uneven wrench motion or bolt friction can cause it to signal a false torque value.

Dial Type Torque Wrench

The dial type torque wrench shows torque values using the needle on a dial (Figure 18). The dial shows the value by pointing to the number that corresponds to the torque value. This type has the most accuracy and is the type recommended when possible. The drawback is that this type can be hard to read in hard to reach places.

TORQUE WRENCH PRECAUTIONS

To ensure torque wrench accuracy, certain precautions must be considered:

- Never use a torque wrench as a pry bar.
- Never use a torque wrench as a hammer.
- Never use a torque wrench to loosen bolts.

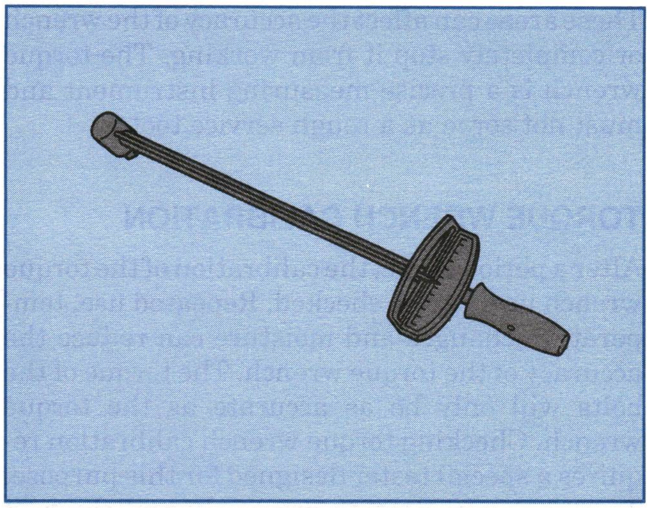


Figure 16. Beam Type Torque Wrench

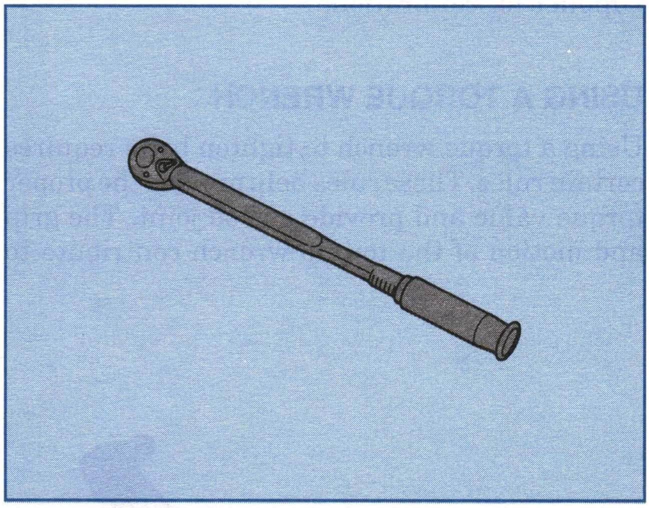


Figure 17. Sensory or Click Type Torque Wrench

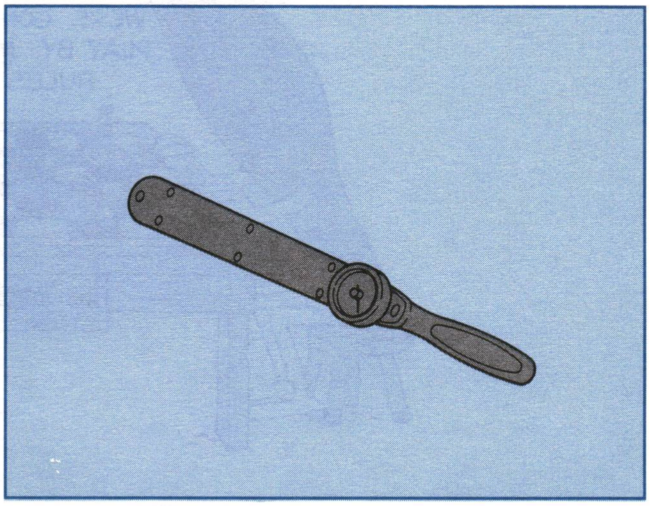


Figure 18. Dial Type Torque Wrench

These areas can affect the accuracy of the wrench or completely stop it from working. The torque wrench is a precise measuring instrument and must not serve as a rough service tool.

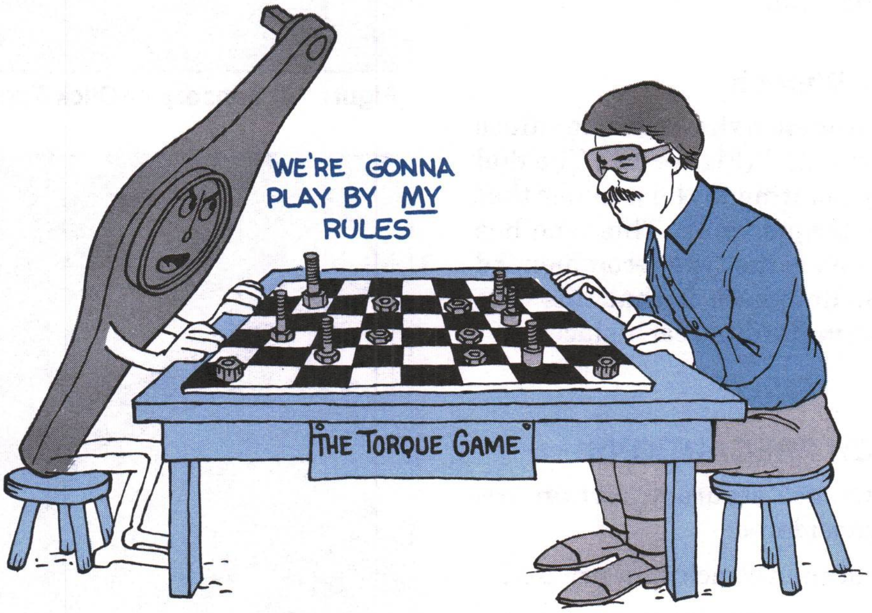
TORQUE WRENCH CALIBRATION

After a period of use, the calibration of the torque wrench needs to be checked. Repeated use, temperature changes and moisture can reduce the accuracy of the torque wrench. The torque of the bolts will only be as accurate as the torque wrench. Checking torque wrench calibration requires a special tester designed for this purpose. Torque wrench testers are costly and the best practice is to take the torque wrench to a tool supplier for calibration.

USING A TORQUE WRENCH

Using a torque wrench to tighten bolts requires certain rules. These rules help provide the proper torque value and provide a good joint. The grip and motion of the torque wrench contribute to the amount of load the bolts deliver. The following rules help control the accuracy of the load distributed by the bolts:

- The threads of the bolt and bolt hole must be clean.
- The clamping surfaces must be clean and free of burrs and old gasket material.
- The bolt threads must be lubricated unless otherwise specified.
- The torque wrench must be calibrated.
- The torque wrench must be pulled at a moderate, even speed until reaching the torque value.
- The torque wrench must not stop and restart during tightening.
- Torque specification must be used.
- Torque sequence must be followed on multiple bolt applications.
- The torque should be applied in a minimum of three steps.


WE'RE GONNA PLAY BY MY RULES
THE TORQUE GAME

USING A TORQUE WRENCH

Torque Wrench Motion

The motion of the torque wrench is critical to the loading of the bolts. A smooth motion at a moderate speed should be used. This allows the tension to build at an even rate and stops the torque wrench from becoming too stressed. If the wrench must be stopped during the torquing motion, you must first back the fastener off slightly before proceeding with the torquing again. The reason for this is that the force necessary to start the bolt again will create an inaccurate reading on the torque wrench.

Torque Sequence

Torque sequence refers to the order used to tighten multiple bolts. Using the proper sequence ensures that the surfaces will be clamped evenly. This allows the surfaces to move and settle as the bolts apply the load. On applications that use a gasket between the surfaces, it allows the gasket to flatten out and provide a better seal. Consult the Shop Manual for the proper torque sequence before assembly (Figure 19). Failure to follow the proper torque sequence causes damage to the components.

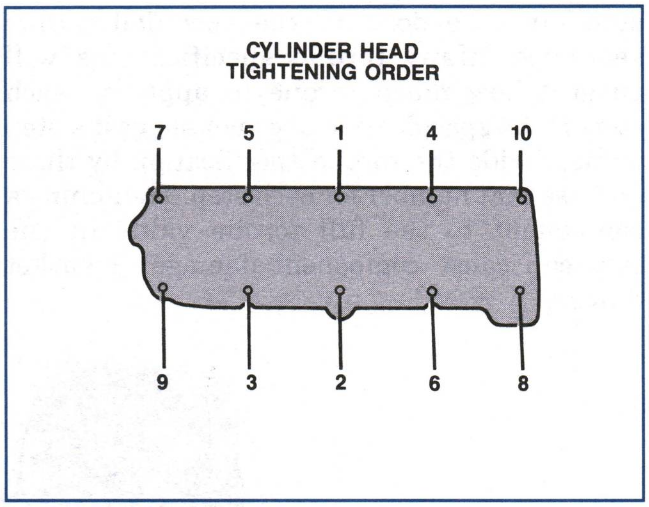
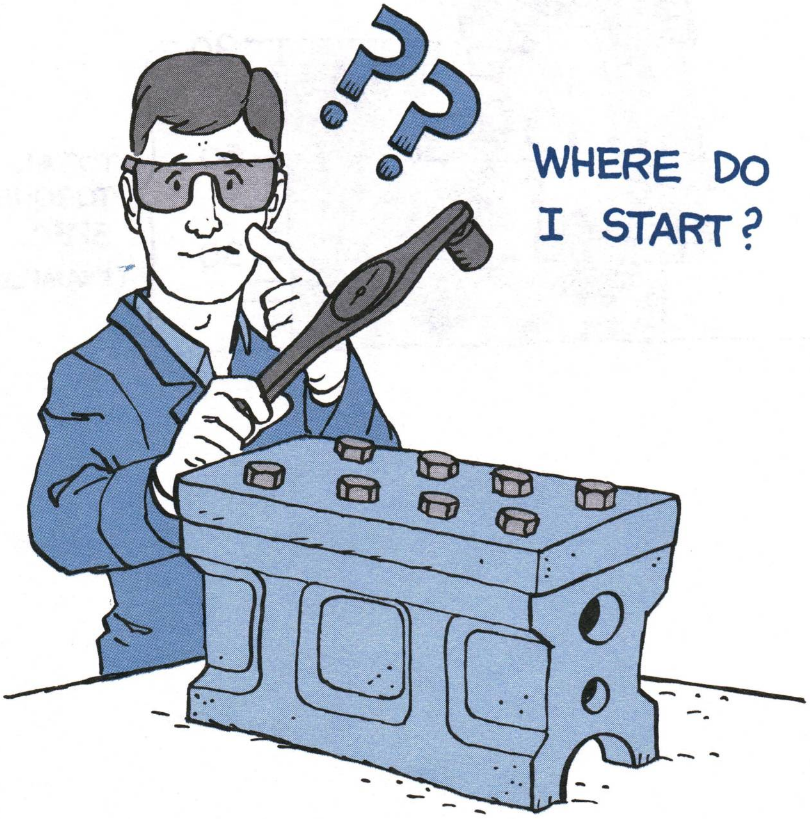


Figure 19. Torque Sequence

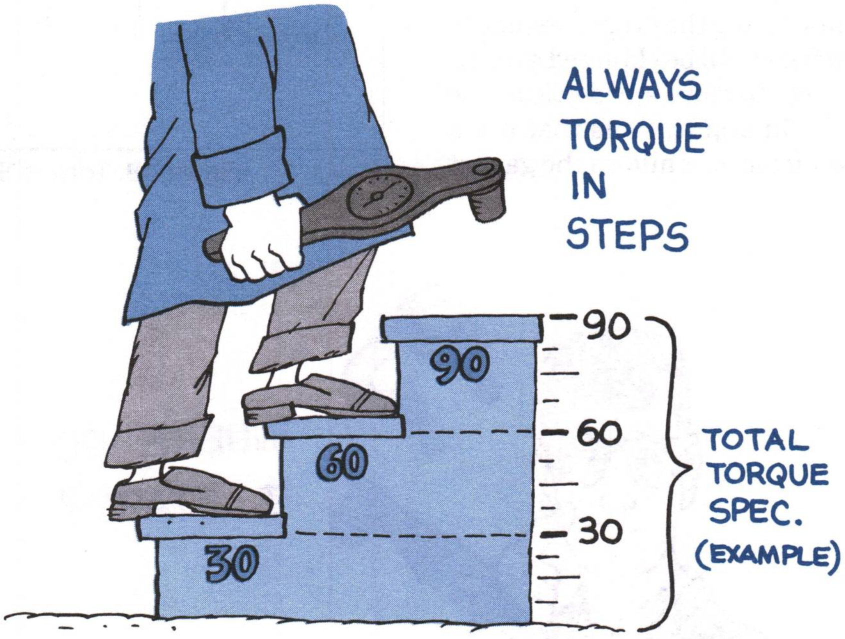

WHERE DO I START?

Torque in Steps

Multiple fasteners must be tightened not only in the proper sequence, but in steps. Three steps are normally used to reach the specified torque. Each step tightens the bolts more. The final step will always be the specified torque value. Each step must be done in the specified torque sequence. Many torque specifications will suggest how much torque to apply on each step. If the specification does not suggest a step value, divide the torque specification by three and use that number for each step. Tightening a component to the full torque value in one step can cause component damage or gasket failure.

Re-torque

Some gasket applications require the use of a re-torque procedure after a certain period. The gaskets in these applications need time in service to compress fully. When this occurs, the bolts lose tension due to the gasket flattening out more. The re-torque procedure requires performing the final torque sequence again. Some replacement gasket packages state if a re-torque will be necessary for that gasket. The Shop Manual is normally the best reference for determining the need for re-torque.



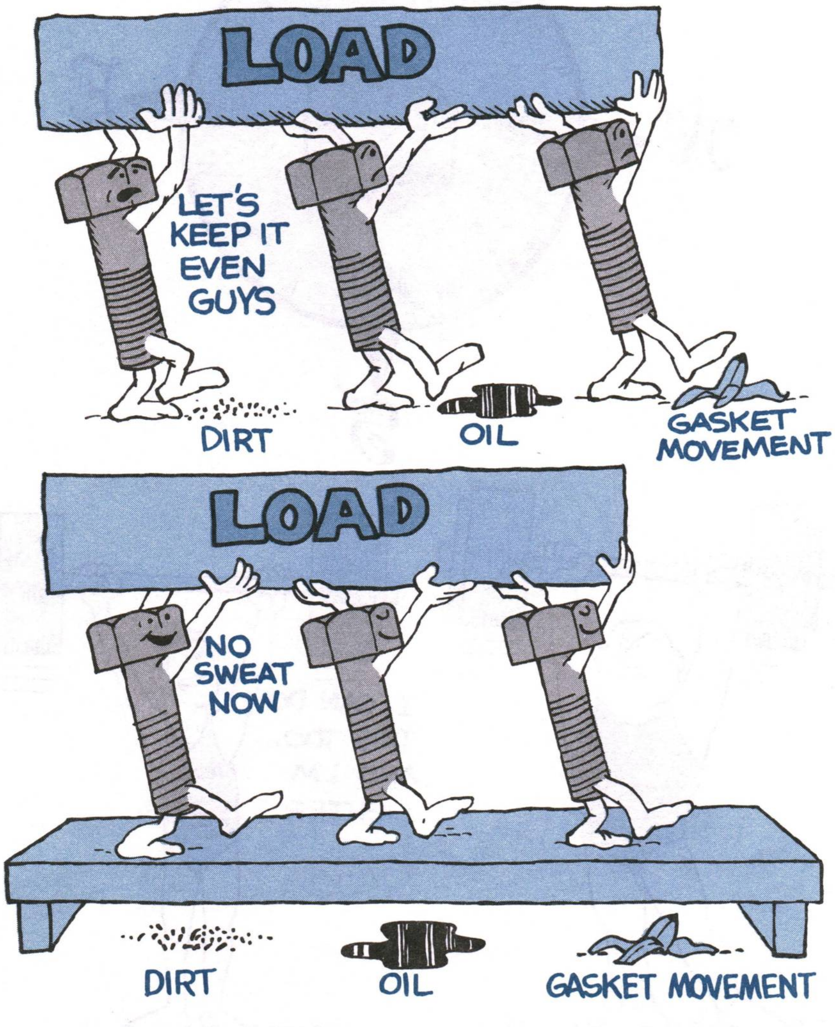
TORQUE TO YIELD

TORQUE TO YIELD CONCEPT

Most bolts provide a certain amount of clamping force while remaining within their elastic limits. The idea has been to keep them within these limits so they will return to their original shape when loosened. Torque to yield bolts work a little differently. Tightening a bolt to the yield point allows it to provide more clamping force. Yield point refers to an area just past the elastic limit where the bolt gives the most clamping force. Tightening the bolt further than the yield point will not show an increase in clamping force. Having passed the bolt's elastic limit means the bolt cannot be reused. Tightening these bolts a second time increases the chances of breaking due to fatigue.

NOTE: Do not reuse torque to yield bolts.

Torque has been the traditional method for determining how much to tighten a bolt. With perfect control over torque, the variation in the load delivered by the bolts is high. Friction, gasket compression and surface movement cause this. Torque to yield bolts help compensate for these areas and provide a more even distribution of the load. This method is possible due to these bolts being precision fasteners.



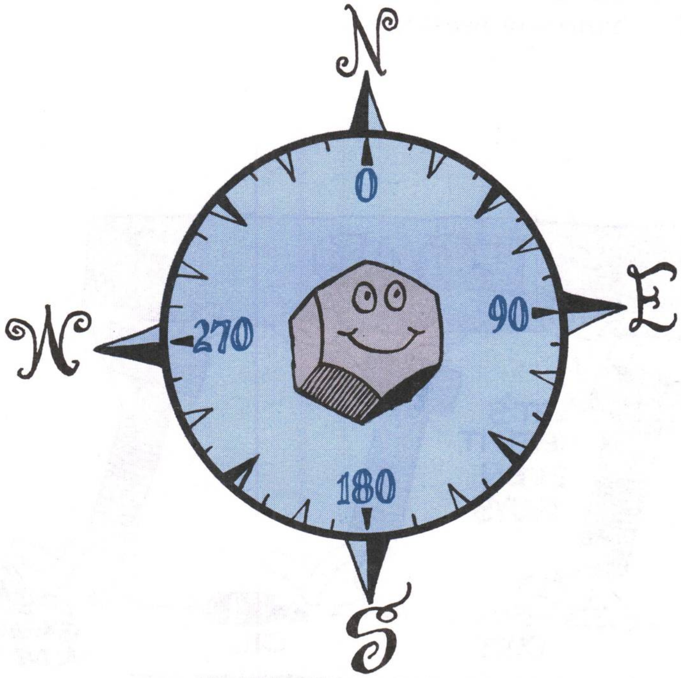
TORQUE TO YIELD

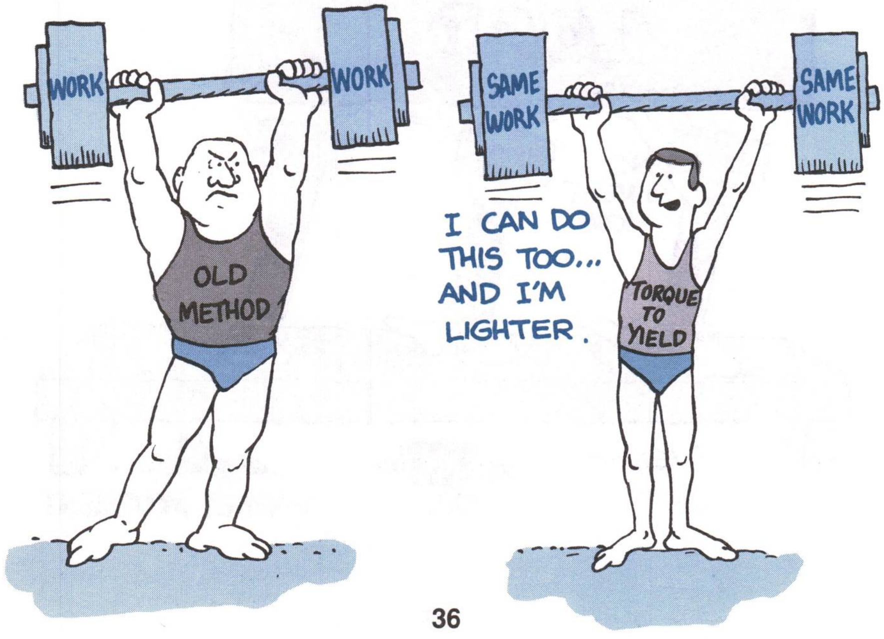
In addition to a torque specification, the manual will show how many degrees these bolts need to be turned. The specifications refer to degrees of rotation instead of foot-pounds or Newton-meters. The bolt head represents a full circle or 360 degrees. A specification of 90 degrees requires turning the bolt 1/4 turn. The gain from this method is that there will be less variation in the load delivered by the bolts. Having less variation between bolts allows them to be turned in equal amounts.

The 4.6L engine uses these bolts for the cylinder head, main bearing caps and connecting rods.

ADVANTAGES OF TORQUE TO YIELD FASTENERS

Torque to yield fasteners provide two advantages. They provide more consistent clamping force and help reduce engine weight. This tightening method overcomes many factors that affect the torque specification method. By tightening bolts to the yield point, a smaller bolt applies the same force as larger bolts would. Since bolt size determines component size, a smaller bolt allows the component to be smaller and lighter. Reducing weight adds to the total efficiency of the vehicle.





TORQUE TO YIELD PROCEDURE

PRECAUTIONS FOR TORQUE TO YIELD

Before assembling a torque to yield application, precautions must be taken to ensure the accuracy of the adjustment. The following precautions apply to torque to yield applications:

- The surfaces must be clean and free from burrs and old gasket material.
- The bolt hole threads must be clean.
- The bolt must be new and have clean threads.
- The bolt threads must be lubricated unless specified otherwise.
- Locate the specifications and tightening sequence.

These precautions help ensure that this method of tightening gives the best possible joint and seal.

TORQUE TO YIELD METHOD

The method for tightening torque to yield bolts is similar to the torque wrench method. Tightening occurs in steps and the sequence is specified. The surfaces still must be brought together in a certain pattern to prevent distortion.

The first step requires the use of a torque wrench. The bolts are tightened to specification in sequence. This gets the bolts to an even starting point and preloads the surfaces.

The last two steps require turning the bolts the specified number of degrees in sequence (Figure 20). Do not use the torque wrench for these two steps. After the final tightening sequence the bolts should be at the yield point.

Example: 4.6L Cylinder Head Bolts

Step 1: Torque bolts 20-30 N·m in sequence

Step 2: Rotate bolts 90 degrees in sequence

Step 3: Rotate bolts an additional 90 degrees in sequence

During the final two steps the motion of the wrench is not important. It is normal for the wrench to feel soft or mushy during the last sequence. If the wrench stops during these steps it will not affect the tightening like it does with a torque wrench. Turning the specified number of degrees is the only concern.

In hard to reach areas it may be necessary to use scribe lines to figure out the degrees of rotation. After the first step, scribe lines on the cylinder head at the 0, 90 and 180 degree positions (Figure 20). Scribe a line on the bolt head even with the 0 degree line. During the last two sequences these lines help keep track of how much the bolt turns.

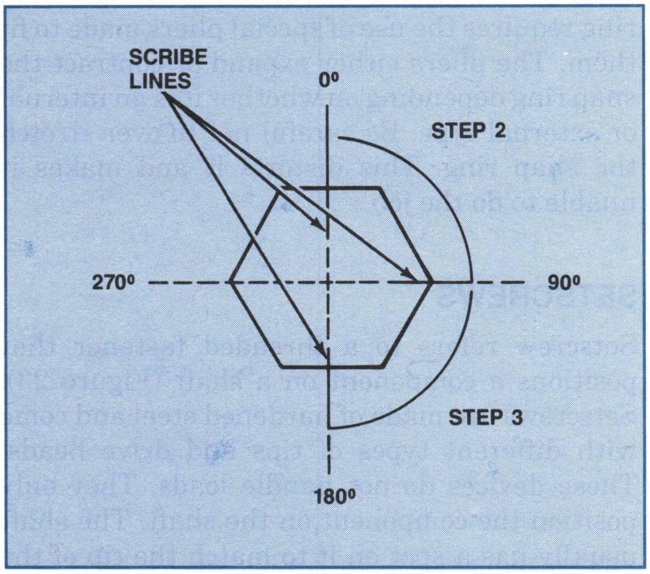


Figure 20. Scribe Line Method

SHEET METAL SCREWS

Sheet metal screws fasten thin metal surfaces together (Figure 21). Tapered threads allow them to form threads in the surfaces during tightening. To use a sheet metal screw, a pilot hole must be drilled or punched into the surfaces. Then as the screw turns into the hole it cuts threads to match the pattern on the screw.

SNAP RINGS

Snap rings position components like gears and bearings (Figure 22). They are made of spring steel in a certain diameter. Snap rings do not apply a load. They only keep a component from moving outside a certain area. Installing a snap ring requires the use of special pliers made to fit them. The pliers either expand or contract the snap ring depending on whether it is an internal or external type. Be careful not to over stretch the snap ring. This distorts it and makes it unable to do the job.

SETSCREWS

Setscrew refers to a threaded fastener that positions a component on a shaft (Figure 23). Setscrews are made of hardened steel and come with different types of tips and drive heads. These devices do not handle loads. They only position the component on the shaft. The shaft usually has a spot on it to match the tip of the setscrew. Before tightening, be sure to line the setscrew up with this spot to ensure proper alignment of the component.

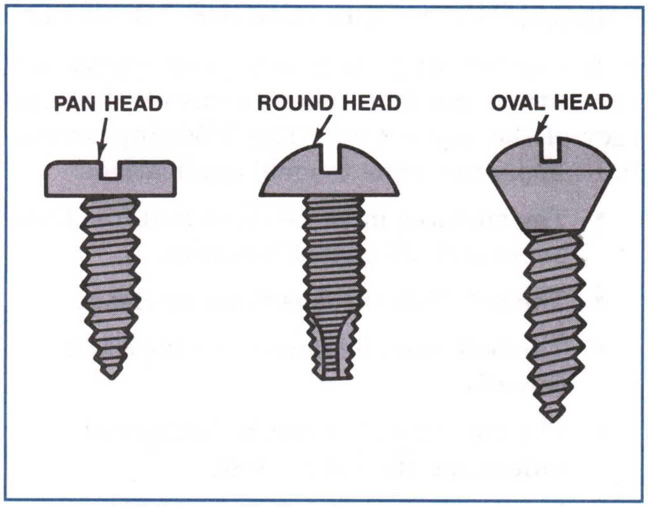


Figure 21. Sheet Metal Screws

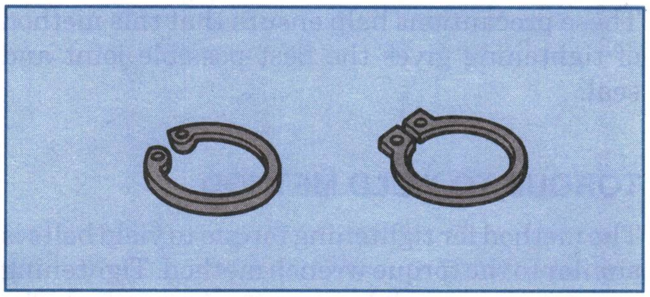


Figure 22. Snap Rings

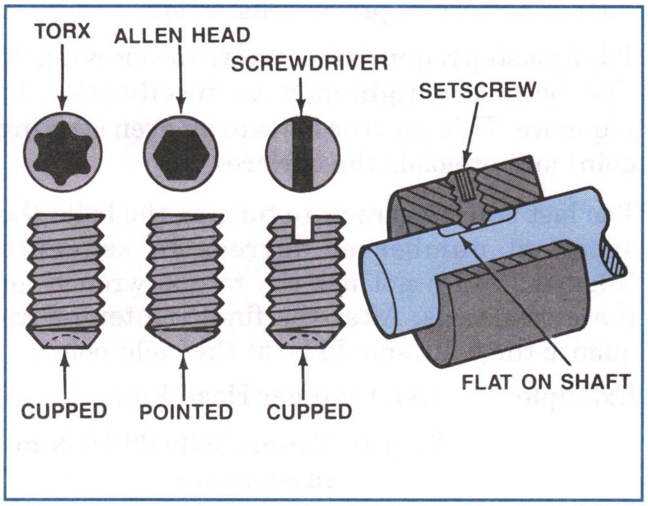


Figure 23. Setscrews

RIVETS

Rivets are fasteners that physically distort to hold sheet metal or plastic together (Figure 24). Rivets come in many different metals and plastics depending on the application. They require the use of a special tool for installation and must be drilled out for removal. When using rivets, make sure they cannot move from side to side and the surfaces are held together firmly.

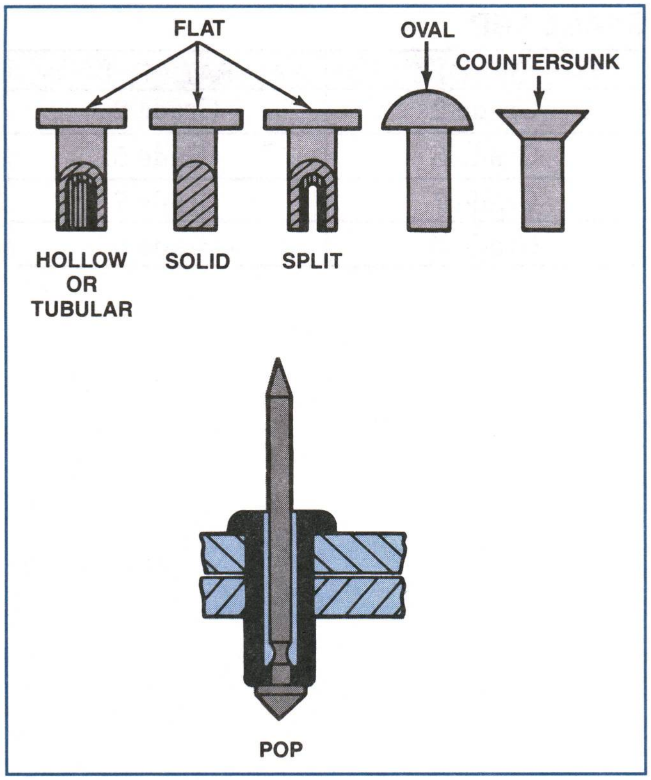


Figure 24. Rivets

BOLT AND NUT GRADE USAGE

STANDARD

SAE BOLT	SAE NUT
Grade 2	Grade 2
Grade 5	Grade 5
Grade 7	Grade 7
Grade 8	Grade 8

METRIC

METRIC BOLT	METRIC NUT
Class 5.8	Class 5
Class 8.8	Class 8
Class 9.8	Class 9
Class 10.9	Class 10

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